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NAVAL POSTGRADUATE SCHOOL
MONTEREY, CALIFORNIA

THESIS

A MANPOWER MODEL AND STRUCTURAL ANALYSIS FOR A COAST GUARD ENLISTED RATING

by

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September 1993

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REPORT DOCUMENTATION PAGE

1a Report Security Classification: Unclassified		1b Restrictive Markings	
2a Security Classification Authority		3 Distribution/Availability of Report	
2b Declassification/Downgrading Schedule		Approved for public release; distribution is unlimited.	
4 Performing Organization Report Number(s)		5 Monitoring Organization Report Number(s)	
6a Name of Performing Organization Naval Postgraduate School	6b Office Symbol (if applicable) *OR	7a Name of Monitoring Organization Naval Postgraduate School	
6c Address (city, state, and ZIP code) Monterey CA 93943-5000		7b Address (city, state, and ZIP code) Monterey CA 93943-5000	
8a Name of Funding/Sponsoring Organization	6b Office Symbol (if applicable)	9 Procurement Instrument Identification Number	
Address (city, state, and ZIP code)		10 Source of Funding Numbers	
		Program Element No	Project No / Task No / Work Unit Accession No

11 Title (include security classification) A MANPOWER MODEL AND STRUCTURAL ANALYSIS FOR A COAST GUARD ENLISTED RATING

12 Personal Author(s) Mark J. Fiebrandt

13a Type of Report	13b Time Covered From To	14 Date of Report (year, month, day)	15 Page Count
Master's Thesis		93 Sep 23	166

16 Supplementary Notation The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government.

17 Cosati Codes			18 Subject Terms (continue on reverse if necessary and identify by block number)
Field	Group	Subgroup	Manpower Models, Vacancy Models, Personnel stocks and flows, TISADV, Coast Guard Personnel

19 Abstract (continue on reverse if necessary and identify by block number)

The Coast Guard must maintain a balance of personnel inventories to billet requirements while providing adequate promotion opportunities. Future changes in billet requirements must be studied to see the effects they may have on the personnel system. This thesis presents a vacancy personnel model based on Markov theory to forecast future end of year inventories and personnel flows for a seven paygrade Coast Guard rating. The model uses historical data and user input to estimate certain model parameters and executes a five year forecast in a spreadsheet format. Certain real life constraints for promotions and recruitment are also incorporated into the model which is then solved in a manner to minimize end of year differences between personnel inventories and billet requirements. In addition, the model estimates, for each forecasted year, a mean Time in Service to Advancement (TISADV) for those promoted to each paygrade based on linear regression and/or weighted multiplier values. The model, called "Coast Guard Rating Forecast Model", is tested for the Machinist Mate (MK) rating using 1984 - 1988 data and validated against 1989 - 1991 actual values. Finally, the model is used to forecast 1993 through 1997 inventories, personnel flows and TISADV values for the MK rating based on beginning of fiscal year 1993 information.

20 Distribution/Availability of Abstract	21 Abstract Security Classification	
xx unclassified/unlimited __ same as report __ DTIC users	Unclassified	
22a Name of Responsible Individual Paul R. Milch	22b Telephone (include Area Code) (408) 626-2882	22c Office Symbol OR/Pe

DD FORM 1473,84 MAR 83 APR edition may be used until exhausted security classification of this page
All other editions are obsolete Unclassified

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A Manpower Model and Structural Analysis
for a Coast Guard Enlisted Rating

by

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Submitted in partial fulfillment
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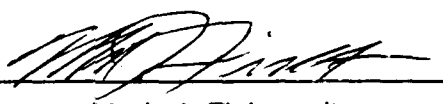
MASTER OF SCIENCE IN OPERATIONS RESEARCH

from the

NAVAL POSTGRADUATE SCHOOL
September, 1993

Author: 

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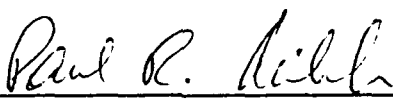
Approved by: 

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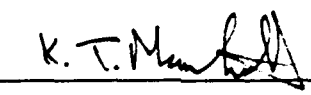

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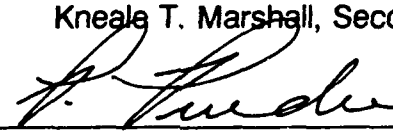

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ABSTRACT

The Coast Guard must maintain a balance of personnel inventories to billet requirements while providing adequate promotion opportunities. Future changes in billet requirements must be studied to see the effects they may have on the personnel system. This thesis presents a vacancy personnel model based on Markov theory to forecast future end of year inventories and personnel flows for a seven paygrade Coast Guard rating. The model uses historical data and user input to estimate certain model parameters and executes a five year forecast in a spreadsheet format. Certain real life constraints for promotions and recruitment are also incorporated into the model which is then solved in a manner to minimize end of year differences between personnel inventories and billet requirements. In addition, the model estimates, *for each forecasted year, a mean Time in Service to Advancement* (TISADV) for those promoted to each paygrade based on linear regression and/or weighted multiplier values. The model, called "Coast Guard Rating Forecast Model", is tested for the Machinist Mate (MK) rating using 1984 - 1988 data and validated against 1989 - 1991 actual values. Finally, the model is used to forecast 1993 through 1997 inventories, personnel flows and TISADV values for the MK rating based on beginning of fiscal year 1993 information.

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EXECUTIVE SUMMARY

The Coast Guard must continuously monitor its personnel workforce to ensure its personnel inventories match the number of authorized jobs. This matching of totals must be done for each grade in the officer corp and for each of nine paygrades and 24 job specialty areas (ratings) in the enlisted ranks. The complexity of this task in tracking the inventories is exaggerated by the constant movement of personnel within and in and out of the Coast Guard manpower system. This movement of personnel is driven primarily by attrition, a factor over which the Coast Guard has little control. The number of personnel who attrite determines the number of promotions between paygrades as well as the number of recruits needed. Therefore, it is necessary to predict attrition rates and use these values to determine flows of personnel between paygrades, recruitment of new personnel, and to estimate end of year inventories. These estimated values are required for two primary reasons:

- End of year inventories should match end of year job (billet) requirements for each paygrade and rating.
- Promotion opportunities must be sufficient to keep top quality personnel from leaving the service.

This thesis develops a mathematical model called the "Coast Guard Rating Forecast Model", for one Coast Guard rating (Machinist Mate). It forecasts annual flows of personnel between paygrades, recruitment into the rating, and

end of year inventories for five one year periods. In addition, the model also forecasts annually the mean Time in Service required for Advancement (TISADV); a value which is used as a measure of promotion opportunity. TISADV is the number of years in service required by the average person to advance to a certain paygrade. These inventories, flows, and TISADV values are needed to review proposed changes in the required number of jobs as presented in the annual Manning Requirements document (MANREQ) and may be used as a planning tool in personnel management. The model is programmed in spreadsheet format using Microsoft Excel 4.0.

The model operates on one Coast Guard rating because of the independent characteristics that are present in a rating with respect to the overall Coast Guard manpower system, as there are few transfers of personnel between two different ratings. Therefore, all entries into a rating is due to recruitment and all departures from it is considered attrition. All flows within the rating are either promotions to the next higher paygrade or demotions to the next lower paygrade. The model forecasting methodology is generic enough to be adapted for any of the 24 enlisted ratings of the Coast Guard.

The model also incorporates certain "real life" constraints for promotions and recruitment. The promotion constraints are required because of possible limitations in qualified promotable personnel or to reduce variability in promotion rates for consecutive years. Recruitment into a rating comes mostly from graduates of technical "A" schools. These schools have certain minimum and

maximum student quotas and these values must be included in the model to limit recruitment within those values.

The user of the model will see two sections of input parameters which are needed for the forecasting process. The first consists of specific values in the model run, such as beginning of year values, predicted attrition rates, and certain constraint parameters. The second section consists of historical inventories, personnel flows and Time in Service values that are found through a program conducted in SPSS 4.0. The historical data are required for the estimation of model parameters. Once all input is provided in the model, the model immediately computes five annual forecasted results. The user may then wish to modify certain input values to see the affected changes on model results.

The Coast Guard Rating Forecast Model was validated in the thesis by comparing model results with observed historical values and then implemented in forecasting the Machinist Mate rating for fiscal years 1993 through 1997. The results are provided as an Appendix to the thesis.

Use of the model can provide an instant source of information which would otherwise require manual calculations and it can be of great benefit to its users in helping them make decisions for the future of the Coast Guard's workforce. It is hoped this model will be used by Coast Guard workforce planners in future years and be implemented for each of the 24 Coast Guard ratings.

I. INTRODUCTION

The United States Coast Guard is a military organization of approximately 33,000 personnel. The main component of this workforce (80%) is the enlisted personnel. The enlisted personnel are divided into nine levels or paygrades, the lowest of Seaman Recruit (E1) and the highest enlisted paygrade of Master Chief Petty Officer (E9). As one advances beyond the Seaman (E3) paygrade, the enlisted person will obtain one of the 24 designated ratings in the Coast Guard. A rating is like an occupation or specialized skill which determines the responsibilities or type of duties that person will perform. Most are sent to school for training in a particular rating and acquire their designator upon graduation. This designator is usually carried through to the remainder of the enlisted persons career.

There is usually little movement of personnel between ratings. This tends to establish independent and separate manpower systems for each rating. Movement of personnel occurs in and out of the rating as recruitment and attrition while promotions and demotions occur within the rating to different paygrades. Thus it is possible to analyze a specific rating on its own and forecast future stocks and flows of personnel in that rating system.

The manning requirements of the Coast Guard organization, and each rating, is determined by an authorized workforce or Full Time Equivalent billet allowance. This authorized workforce is documented as a list of jobs or billets

for all Coast Guard units on the Personnel Allowance List (PAL). From this list is the establishment of a workforce structure which prescribes the number of billets or jobs in each paygrade for a specific rating. This personnel requirements billet structure must be matched with actual personnel with minimum deltas between the two desired for all ratings and paygrades. Since workforce requirements are constantly revised as units change or manning requirements reset, and personnel resources fluctuate, frequent examination of resources and requirements is necessary.

Personnel movements to different paygrades are driven primarily by attrition. As someone leaves the system, a vacancy may occur as an unfilled authorized billet. A vacancy can be defined as the difference in the number of authorized billets in a rating and paygrade and the actual number of personnel in the same rating and paygrade. Promotions are then granted to fill vacancies and recruitment to the lower paygrade levels are made to build the junior personnel workforce. This must be conducted while ensuring proper qualifications of personnel, minimum standards in time in service, and maintenance of proportionate paygrade levels.

Opportunities to advance to higher paygrades have an effect on career choices and personnel attrition. Less opportunity to advance causes increased attrition. A good measure of advancement opportunity is the Time in Service to Advancement (TISADV) of an individual. By calculating the mean TISADV for those advanced to a certain paygrade, it can be compared from year to year to

see how long it takes the average person to make that paygrade. If values are increasing, then advancement opportunity is decreased and should negatively impact attrition rates.

Workforce structure modelling is of major interest to the Coast Guard in developing recruiting goals and plans, projecting "A-school" requirements and flows, monitoring "overhead" requirements (i.e. general detail personnel), monitoring loss rates, analyzing Personnel Allowance List amendments, and in developing workforce structure models that analyze changes to the workforce. This must not only be conducted on an aggregate basis for the entire Coast Guard workforce structure, but also for each specific enlisted rating. Thus over 24 separate force structures must be monitored to ensure matching of personnel levels with authorized personnel allowances without negatively impacting career opportunities in the enlisted ratings.

A. OBJECTIVES

The objective of this thesis is to develop a manpower model for one enlisted rating that will act as a guide or test model for future development of individual models on each Coast Guard rating. This model will be entitled "The Coast Guard Rating Forecast Model". The primary purpose of the model is to evaluate the Manning Requirements Forecast (MANREQ). This document, which is issued at the beginning of a fiscal year, forecasts changes in the workforce requirements or authorized billet list through the end of the year. The Workforce Planning division of Commandant, U.S. Coast Guard must comment

on how the changes will affect the personnel workforce for the coming year and in the long term. This is done by looking at each individual rating and reviewing the effects of the changes.

The thesis has two specific primary objectives:

- to construct a mathematical model to forecast future rating force structure, given a current workforce requirement billet structure and known personnel manning levels, and to specify promotion rates, attrition rates and recruitment into the rating for a fiscal year and up to four one year periods following. This must be done while maintaining certain minimum flow levels. This model shall be implemented using a standard commercial spreadsheet computer program that is exportable to an IBM 486/PC.
- to evaluate changes to Time in Service to Advancement (TISADV) as certain model variables change. Specifically to answer the question: "How do changes in authorized personnel allowances, promotion rates, and attrition rates affect TISADV?" The intent in tracking TISADV will be to establish a comfortable equilibrium point where differences between authorized billets and actual personnel levels are minimized while TISADV levels remain adequate to entice sufficient numbers of quality personnel to remain with the Coast Guard workforce. Certain guidelines do exist which establish "ideal" TISADV values which will be evaluated and targeted as model objectives.

B. COAST GUARD ENLISTED WORKFORCE

Within the Coast Guard's enlisted ratings, there are six rates. They are from highest to lowest: master chief, senior chief, chief, first class, second class, and third class. These rates are sometimes identified by paygrade as E9 through E4 respectively. In addition, paygrades E1 through E3 are also considered as part of the rate structure but do not normally possess designated ratings.

The enlisted workforce is very dynamic in that movement of individuals within the structure is constantly evolving. This continuous movement process occurs as personnel enter or depart the Coast Guard, move into and out of ratings, and as promotions or demotions of personnel occur.

1. Recruitment Into a Rating

Recruit personnel are generally thought of as E1 personnel entering the Coast Guard from the civilian world and going to boot camp for basic training. Recruitment into a rating is similar in meaning in that Coast Guard personnel are recruited or entered into a rating. This usually occurs in one of four ways:

a. "A" School Training

This category generally represents the majority of those who get recruited into a rating. Non-rated personnel are selected for "A" school training to learn and qualify for a specific rating. Once graduated and meeting other time in grade and military requirements, those personnel assume a rating

designator and paygrade of E4. Sometimes personnel have disciplinary problems or are sent to "A" school as an E2 and don't meet all the qualifications for advancement to E4 upon graduation. Those graduating personnel are then given the rating designator in their current paygrade of E2 or E3.

b. Promotion

Personnel may be recruited into a rating by advancement from E3 after completing the appropriate correspondence courses and then competing in a Servicewide examination. Once promoted to E4, the rating designator is obtained.

c. Prior Service Recruitment

Occasionally, personnel with prior military service are recruited from the civilian world and enter directly into an enlisted rating. This may occur within any paygrade.

d. Change in Rating

Personnel sometimes wish to change ratings from one to another or the needs of the Coast Guard requires personnel to switch ratings. This may result in personnel being recruited into a rating at any paygrade level. Changes in rating occur infrequently. Any significant changes in rating would be a result of changes in Coast Guard manpower requirements.

2. Attrition From a Rating

Attrition is generally thought of as personnel exiting the Coast Guard. But when personnel attrite from a rating, they either get out of the Coast Guard

or move into a different segment of the Coast Guard force structure. The most common forms of attrition from a rating are:

- exiting the Coast Guard,
- changing ratings,
- promotion to Warrant Officer,
- selection to Officer Candidate School, and
- demotion resulting in removal of designator.

3. Promotions Within a Rating

Promotions are vacancy driven. That is, as vacancies occur within a rating and paygrade, personnel are promoted to fill the vacancy. Promotees are selected on the first of each month from those personnel at the top of the promotion list. To be entered on the promotion list, one must first be eligible for promotion, then compete in the semi-annual servicewide exam. Eligibility consists of passing appropriate correspondence courses, meeting certain performance and military standards, having a minimum time in paygrade, and minimum time in service. The minimum time in paygrade requirement varies from six months for E2 through E4, 12 months for E5, 24 months for E6, 36 months for E7, and 24 months for E8 to advance to the next higher paygrade. Time in service (TIS) requirement, which is the total active duty time, only exists for E8 as ten years minimum TIS, and E9 as 12 years minimum TIS.

Once eligible for promotion, personnel then compete in the servicewide examination with all other eligible personnel in the same rating and

paygrade for a position on the promotion list. Once a promotion list is established, it stays current for the next six months until the next servicewide exam period. The Coast Guard then sets a cut-off point on the promotion list which is a predicted number of promotions that will occur during that six month period. Those above the cut-off are either promoted during the six month period or guaranteed to be promoted first in the following period. If more promotions are needed then what was predicted, personnel from below the cut-off are promoted. Those not promoted and below the cut-off must compete again on the servicewide exam for entry to future promotion lists.

4. Demotions Within a Rating

Due to administrative or disciplinary actions, sometimes demotions occur within a rating. These usually occur in the lower to middle paygrades and affect only a small fraction of the rating population. Occurrences are on a case by case basis and may happen at any unscheduled time. When a demotion does result, it is usually down one paygrade.

C. COAST GUARD MANPOWER REQUIREMENTS

The number and characteristics of human resources needed to perform the missions of the Coast Guard requires extensive mission analysis by many components of the planning process. Program managers must evaluate mission functions, while facility managers determine the best mix of hardware resources, and the Personnel Program Director determines the best mix of personnel. This mix when aggregated for the entire Coast Guard results in a

structured enlisted workforce requirement consisting of 24 ratings and nine paygrades. Each billet or job is documented and listed on the Personnel Allowance List and then summarized once a month by the Monthly Summary of Military Billets issued by the Commandant (CPA-2).

D. MODEL FORMULATION APPROACH

The model proposed in this thesis relies on Markov theory and adopts the concept of instantaneous movements of vacancies initiated by attrition from the rating [Ref. 1: p. 146]. Model parameters will be estimated based on historical data. Therefore, the accuracy of future predictions by the model will rely on the assumption that future personnel movements will follow the same trends as those in the data analyzed.

Chapter II of this study will focus on the analysis of data and the estimation of model parameters. Specifically, the chapter will detail the use of historical data to estimate parameters that will be used in forecasting future manning stocks and flow rates in the manpower forecasting model. Chapter III will formulate the basic forecasting model and develop the parameters which specify the changes in the Time in Service to Advancement values. Chapter IV will then validate the basic model to ensure proper execution and acceptable results. This chapter will also implement the model in forecasting future promotion rates, recruitment levels, and TISADV values based on the latest data provided. The results will be reviewed and analyzed in order to verify that the model has in fact met the stated objectives. Chapter V will synthesize the

results of the previous chapters and present a summary of conclusions and recommendations.

II. DATA ANALYSIS

A. DISCUSSION

This thesis will construct a manpower model that predicts future inventories, promotion rates, and recruitment within the Machinist Mate (MK) rating. It will be achieved using MARKOV theory [Ref. 2: p. 135-200] to view vacancy movements in the manpower system from one paygrade category to another during one year time periods. The system will consist of seven paygrade categories (E3 through E9). Vacancy models are based on the premise that job openings or billet vacancies will occur in the system. These vacancies are then filled from within the system by movement of personnel from one category to another or by recruitment to the system. Vacancy models are sometimes called "pull" models because when a vacancy occurs, it pulls personnel from other categories or from outside the system to fill those vacancies. In an instantaneous vacancy model, movements occur instantly as a vacancy occurs and can instantly create new vacancies and movements in the system. For example an attrition at the E9 level can cause promotions from the E8 level and subsequently from each lower category until recruitment into the E3 or E4 level fills the vacancy in the system.

The manner in which vacancies are filled (i.e. promotions, demotions, or recruitment) depend on vacancy model transition rates. Transition rates may be defined as the proportion of vacancies in one category filled by personnel

from another category. These rates, the parameters of the vacancy model, can be estimated from historical data. This requires the analysis of personnel movement data and the assumption that future system movements will behave similarly to past movements.

This chapter will discuss the available historical data in order to view trends in personnel movements and to produce estimates of transition rates for forecasting future inventories. Specifically, estimates of all personnel movement rates, such as recruitment to the system, attrition out of the system, promotion rates and demotion rates will be discussed.

B. DATA AVAILABILITY

The office of Personnel Workforce Planning (G-PWP) at Coast Guard Headquarters has two primary historical data files available to them for analysis.

1. Census File

The first file consists of census data containing a record for every member of the Coast Guard on the last day of the fiscal year (30 Sept) for a period of eight consecutive fiscal years (1983 to 1991). This file contains approximately 330,000 records with over 30 fields of data for each record. The fields relevant to this thesis include fiscal year, social security number (SSN), paygrade, date of active duty, and date of rank. Since this paper is only interested in the Machinist Mate (MK) rating, this file was queried to provide only the 33,229 records of data on MK personnel. This was the primary data base used for the analysis of this paper.

2. Separations File

The second data file available to G-PWP personnel is the separations file. This is an annually produced file which contains a record for every member of the Coast Guard who separated from the Coast Guard during that fiscal year. Data was again available for the fiscal years 1983 to 1991 inclusive. However, G-PWP believed that 1990 and 1991 separation files were not complete. Therefore, reliable separation data from these files was only available for the years 1983 to 1989 inclusive.

C. REQUIRED DATA SUMMARIES FOR THE VACANCY MODEL

Vacancy model transition rates may be estimated from annual historical data. This requires five vectors of numerical values, each vector of seven dimensions for the seven paygrades. They are

- annual total number of MK personnel in each paygrade,
- annual number of promotions from each paygrade to the next higher paygrade,
- annual number of demotions from each paygrade to the next lower paygrade,
- annual number of separations from the MK rating for each paygrade, and
- annual number of recruitment into the MK rating for each paygrade.

Many offices at Coast Guard Headquarters were questioned as possible sources for obtaining these vector values. However, it was found that either the data was not available at all or was only partially available from these sources.

It was therefore decided to access all the needed information from the census data file. This included determining the number of separations from the census data vice use of the separations files since reliable separations data was not available for 1990 and 1991. Using only one data source also appears to alleviate problems of data bias, or data inconsistency that would appear from use of multiple data sources.

All data processing was conducted using SPSS version 4.0 and SPSS version 5.0 for windows programs on a 486 personal computer system. The results of the data programming are provided as tables in Appendix A and are discussed below.

1. Total Number of MK Personnel in Each Paygrade (Inventories)

These annual figures were easily determined from the annual census data records by tabulating the number of records by year and paygrade. However, all records with a YEAR value, for example 1983, would be end of year inventory data for that year (e.g. 1983) because they reflected the number of personnel on 30 September. For purposes of this model, however, beginning year inventories are necessary and therefore each year's end inventory was recorded as next year's beginning inventory. This provides the base number of personnel subject to attrition, promotion, etc.

The notation for total number of personnel in paygrade i for beginning of fiscal year yr will be $TOT_i(yr)$, where yr = 1984 through 1991 and i = paygrades E2/3, E4, ..., E9.

2. Number of Promotions

Promotions are assumed to occur to the next higher paygrade only. To obtain the number of personnel promoted on an annual basis from one paygrade to the next higher paygrade, it was necessary to compare successive records of each individual to determine the year that person was promoted. This first required the census file to be sorted by SSN and YEAR both in ascending order. Then a promotion was found by looking at two consecutive records with the same SSN to see if the PAYGRADE variable changed. The first fiscal year a higher paygrade appeared was the fiscal year when a promotion was considered to have occurred. It must be noted that although there are inventory data for nine years (end of year 1983-1991), promotion numbers can only be determined for eight years (1984-1991) since the promotion computation requires two consecutive years of records. This is also true for all other personnel movements determined in this way. It is also noted that this system assumes that only one promotion per individual can occur each year. This assumption holds for advancement to E6 and above since the minimum time in grade is one year or greater in each case. However, advancements to E3, E4, and E5 can occur as rapidly as six months. The data was queried to see if this caused a problem by asking how many double promotions occurred in the same year. Only 21 cases of double promotions occurred of which 15 happened in 1984. This represents less than one-half a percent of single promotions that occurred during the same time. Of the 21 cases, ten were

double promoted in one year to E6 and above. This is physically impossible since a minimum time in grade of one year or greater is required in the E5 through E9 paygrades. It is believed these ten cases are due to data input error. On an annual basis, only two or three occurred each year since 1984 (See Appendix A). Due to the small numbers of double promotions and the fact they may result from input error, these double promotions were deleted from the data. The exact programming required for determining the number of single and double promotions can be found in Appendix B. The promotion table in Appendix A shows the number of single promotions for each year. Each cell of the table represents the number of individuals that were promoted to that paygrade during that year. For example, the cell for year 85 and paygrade E5 shows the number 273. This means that 273 E4 personnel were promoted to E5 during fiscal year 1984. This value will be used as the numerator in determining the promotion rate of E4 personnel during fiscal year 1984. For example, the 1984 E4 promotion rate = # E4 promoted to E5 / # E4 at the beginning of fiscal year 1984 (273/1157 = 0.235).

The notation for promotions to paygrade i during year yr will be $PROM_i(yr)$. For the previous example, $PROM_5(1984) = 0.235$.

3. Number of Demotions

The number of demotions for each year can be found using the census data file in the same manner as determining promotions, except that one must now look for changes to the next lower paygrade. The table for the

number of demotions is found in Appendix A. Each cell of the table represents the number of individuals who were demoted to that paygrade during that year. For the eight year period only 143 demotions occur representing less than one-half of a percent of the population. This is relatively insignificant for the system but is included in the model because they affect the vacancy model results.

The notation for demotions to paygrade i during year yr will be $DEM_i(yr)$.

4. Number of Separations

The file of annual separations contains detailed information on Coast Guard separations, however 1990 and 1991 files appear to be incomplete. In addition, transfers from the MK rating to other categories of the Coast Guard organization, such as Warrant Officer or Commissioned Officer are also of interest. Therefore, instead of using the separations files, the census data files were used to find the total number of separations from the MK rating regardless of whether these individuals separated from the Coast Guard or not. The logic for generating the data looks at successive years of data on individuals. If a person was present in the census data one year and not in the next, then it was concluded that the individual must have separated during the fiscal year. The separations table in Appendix A shows the results. Note that each cell refers to the number of personnel that was in that paygrade at the beginning of the fiscal year and separated during that fiscal year. This allows for easy computation of transitional attrition rates.[Ref. 1: p. 30] That is, the annual attrition rate for

each paygrade can be computed as

$$w(yr) = \frac{SEP(yr)}{TOT(yr)} \qquad (2.1)$$

where $SEP_i(yr)$ is the number of separations during year yr among MK personnel who were in paygrade i at the beginning of that year, and $TOT_i(yr)$ is the total number of personnel at the beginning of year yr in paygrade i.

5. Number of Recruitment

Recruitment into the MK rating can be found from the census files in a similar manner as determining separations. Consecutive years are required for each individual and if that person was present in one year but not in the previous year, then that person was considered to have been recruited into the rating during that year. The recruitment table in Appendix A shows the results.

Recruitment in year yr for paygrade i will be referred to as $REC_i(yr)$.

D. REQUIRED DATA SUMMARIES FOR TIME IN SERVICE

The second objective of this thesis is to evaluate changes in Time in Service to Advancement (TISADV) for promotees. This objective requires determination of historical mean Time in Service (TIS) values for each vector of personnel inventory and the transition variables discussed in the last section. Specifically, mean Time in Service (TIS) values must be determined for:

- all MK personnel in each paygrade at the beginning of each fiscal year (i.e. beginning of year inventories) denoted as $TIS_i(yr)$,
- all promotees from one paygrade to the next higher paygrade during each

fiscal year denoted as $TISADV_i(yr)$,

- all demotees from each paygrade to the next lower paygrade during each fiscal year denoted as $TISDEM_i(yr)$,
- all attritees from the MK rating for each paygrade during each fiscal year denoted as $TISSEP_i(yr)$, and
- all recruits into the MK rating for each paygrade during each fiscal year denoted as $TISREC_i(yr)$

where yr refers to fiscal year and i refers to the paygrade the movement went to or is located. The census file is again relied upon to determine the values of these variables.

The logic for producing these TIS values from the census file is relatively simple. First, the desired records for each data group is separated from the total group (ie. only records for those attrited are used for $TISSEP_i(yr)$ values, etc.). Then the mean TIS value is determined by averaging the differences in the date of each record and the date of active duty in that record. This process gives a mean TIS value for the group at the <u>end</u> of the fiscal year point in time. Making the assumption that personnel flows may occur with equal probability throughout the year, a one half a year correction is needed for most of the mean TIS values. This correction in the mean TIS was performed in the computation of the TIS tables in Appendix A. The $TISADV_i(yr)$ values are produced a little differently. Promotee records are first selected from the census file, then the difference in the date of rank and the date of active duty is

found as the $TISADV_i(yr)$ value. This provides an exact date of TISADV which does not require a correction. The programming required for determining these values can be found in Appendix B and the uses of these mean TIS values will be discussed in the next chapter.

III. MODEL FORMULATION

A. DISCUSSION

The ability of the Coast Guard to perform its missions effectively depends on the personnel workforce. If the workforce is less than the authorized billet allowances, or the wrong mix of personnel to authorized billets exists, then Coast Guard units operate with inadequate personnel. This results in mission degradation. If there exist additional personnel above the authorized billet allowance, then excessive payroll costs result. These reasons and others establish a need to have an equilibrium of billets and personnel. This may be accomplished through effective forecasting of Coast Guard personnel flows and inventory requirements. *This chapter will develop a manpower model to* forecast future personnel flows and inventory requirements for the Machinist Mate rating. The model will be based on seven paygrade categories E2/3 and E4 through E9.

The Coast Guard can reasonably control the number of billets required at a time and can predict its needs for future years with some accuracy. This means the Coast Guard can plan for a certain number of billets and then attempt to match personnel to those billets. The biggest problem with attempting to match personnel with requirements is that the Coast Guard has little control over personnel attrition, the main driving force of personnel movements within the system.

A Vacancy model [Ref. 1: p. 139] operates in the same manner as the Coast Guard system described in the introduction to Chapter I, in that it compares billets to personnel and is driven by attrition. When an attrition occurs in a paygrade, a vacancy is created. This vacancy will result in a series of movements in the system in an attempt to fill the vacancy. When the vacancy is first filled, say by promotion from the next lower paygrade, the vacancy is viewed as having moved into that lower paygrade category. The vacancy now exists in that lower paygrade and must be filled again from some other source. This procedure continues until the vacancy exits the system due to the entry of a recruit at some paygrade category.

This vacancy model is based on Markov theory [Ref. 2: p. 135]. Its main component is a transition matrix whose elements represent the proportion of vacancies in one paygrade category that move to another paygrade category. In the Coast Guard system, vacancies can move from one paygrade to another by promotions and demotions, and out of the system by recruitment.

Vacancy models may be classified as either instantaneous or non-instantaneous. In a non-instantaneous model, a vacancy will move from one category in the system to another only once during a set time period. In an instantaneous model, a vacancy will move as many times as necessary for it to exit the system, all within one period. For example, a vacancy can move from the E7 category to E6 due to a personnel promotion, then from E6 to E5, E5 to

E4, and finally exit the system due to recruitment into E4. Note that vacancies always move in the opposite direction as do personnel.

This thesis develops an instantaneous vacancy model for use in forecasting future promotions, demotions, and recruitment in the Machinist Mate (MK) rating. The model is called the "Coast Guard Rating Forecast Model" and is programmed in Microsoft Excel 4.0 spreadsheet format. It consists of the seven paygrade categories, E2/3 (combined) and E4 through E9. Since one of the primary goals of this thesis is to use the model to forecast end of fiscal year results based on the beginning of year Manning Requirements (MANREQ) document, the time period for one iteration of the vacancy model is a year. This also coincides with the annual nature of the historical data that are available and were discussed in Chapter II.

B. MODEL FORMULATION

Vacancies can be defined as the difference in the number of billets and number of personnel to fill the billets. Expressed as an equation,

$$v_j(t) = n_j(t) - e_j(t) \qquad (3.1)$$

where

- $n_j(t)$ = number of MK billets in paygrade j at time t,
- $e_j(t)$ = number of MK personnel in paygrade j at time t, and
- $v_j(t)$ = number of vacant MK billets in paygrade j at time t

for j = 3, ..., 9 enlisted paygrades. Vacancies can be negative or positive

depending on the values of $n_j(t)$ and $e_j(t)$. If there are more billets than personnel (i.e. $n_j(t) > e_j(t)$), then a shortage of people exists and vacancies, $v_j(t)$, will be positive. On the contrary, if more personnel exist than billets (i.e. $e_j(t) > n_j(t)$), vacancies $v_j(t)$ will be negative representing a surplus of people. From this relationship, a vacancy vector $\underline{v}(t)$, which represents the vacancies in all paygrades j = 3, ..., 9, can be determined at any given point in time t to determine shortages and surpluses in personnel.

The transition rate matrix S in this system is a seven by seven square matrix where each state or category represents a paygrade in the MK rating.

$$S = \begin{bmatrix} s_{3,3} & s_{3,4} & \cdots, & s_{3,9} \\ \cdot & & & \\ \cdot & & & \\ \cdot & & & \\ s_{9,3} & s_{9,4} & \cdots, & s_{9,9} \end{bmatrix} \qquad (3.2)$$

Each element $s_{i,j}$ in the transition rate matrix is defined as the proportion of category i vacancies filled by category j personnel during an iteration of the process, or alternately as the probability that a category i vacancy is filled by a category j person during an iteration. There may be several iterations during a period before a vacancy "exits" the system [Ref. 1: p. 146]. In the MK system, vacancies can only be filled by promotions, demotions, or from outside the system by recruitment. Therefore, in each row of the transition matrix, only two elements $s_{i,i-1}$ (for promotions) and $s_{i,i+1}$ (for demotions) will have positive

values. The remaining $s_{i,j}$ values will all be zero. Since recruitment comes from outside the MK system, an additional column of elements r_i may be positioned alongside the transition matrix. These r_i values represent the proportion of vacancies in paygrade category i that are filled by recruitment. This may be shown as

$$\begin{bmatrix} 0 & s_{3,4} & 0 & 0 & 0 & 0 & 0 & r_3 \\ s_{4,3} & 0 & s_{4,5} & 0 & 0 & 0 & 0 & r_4 \\ 0 & s_{5,4} & 0 & s_{5,6} & 0 & 0 & 0 & r_5 \\ 0 & 0 & s_{6,5} & 0 & s_{6,7} & 0 & 0 & r_6 \\ 0 & 0 & 0 & s_{7,6} & 0 & s_{7,8} & 0 & r_7 \\ 0 & 0 & 0 & 0 & s_{8,7} & 0 & s_{8,9} & r_8 \\ 0 & 0 & 0 & 0 & 0 & s_{9,8} & 0 & r_9 \end{bmatrix} \tag{3.3}$$

Each row in the transition matrix along with the recruitment element r_i must sum to one; i.e.

$$s_{i,i+1} + s_{i,i-1} + r_i = 1 \qquad i = 3,\ldots,9 \tag{3.4}$$

It will be shown later in this chapter that the promotion elements $s_{i,i-1}$, the demotion elements $s_{i,i+1}$, and the recruitment elements r_i may be estimated by personnel flows between paygrade categories and from the outside.

In defining the transition matrix S as the probabilities of vacancies moving among paygrades within the MK system, the Fundamental matrix D represents the instantaneous flow of vacancies through the system before exiting [Ref. 1:

p. 149]. The Fundamental Matrix is defined as

$$D = (I - S)^{-1} \tag{3.5}$$

Its elements $d_{i,j}$ may be viewed as the number of times a vacancy which enters the system at category i will show up in category j. When matrix-multiplied by the vector of vacancies that exist in each category at the beginning of a time period, it will give the expected number of total vacancies that will be seen in each category at the end of that period. This is expressed as

$$E[\underline{tv}] = \underline{tv}\, D \tag{3.6}$$

where $\underline{tv}$ is the vector of vacancies that exist in the seven paygrade categories at the beginning of a period (t-1, t) and $E[\underline{tv}]$ is the vector of expected total number of vacancies in the seven paygrade categories at the end of that period.

The vector $\underline{tv}$ is determined as the sum of vacancies that originate in one of three ways.

1. Beginning Vacancies

Vacancies may exist at the beginning of a time period (t-1,t) in the system. These are expressed as the differences between the number of billets and the number of personnel at time t-1:

$$\underline{v}(t-1) = \underline{n}(t-1) - \underline{e}(t-1) \tag{3.7}$$

2. Vacancies From Attrition

The primary driving force of the vacancy model is attrition. As a person leaves the system, a vacancy occurs. To forecast vacancies from attrition, we use the beginning population of personnel represented by the vector $\underline{e}(t-1)$ and matrix-multiply it by the attrition rate vector $\underline{w}$. This may be represented as the vector

$$\underline{e}(t-1)\ W \tag{3.8}$$

where W is a diagonal matrix with the diagonal elements being the attrition rates w_i and all other elements being zero. That is,

$$W = \begin{bmatrix} w_3 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & w_4 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & w_5 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & w_6 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & w_7 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & w_8 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & w_9 \end{bmatrix} \tag{3.9}$$

3. New Billets

Vacancies can be created or eliminated, by the adding or deleting of billets. This is commonly done as an organization changes its requirements or size and can be represented by a vector $\underline{m}$ defined as

$$\underline{m}(t) = \underline{n}(t) - \underline{n}(t-1) \tag{3.10}$$

The vector of total originating vacancies in each category can now be

expressed as

$$\underline{v} = \underline{v}(t-1) + \underline{e}(t-1)W + \underline{m}(t) \tag{3.11}$$

From equation 3.6, we find the expected total number of vacancies for each paygrade category as

$$E[\underline{v}] = [\underline{v}(t-1) + \underline{e}(t-1)W + \underline{n}(t) - \underline{n}(t-1)] \times D \tag{3.12}$$

and for each paygrade category j

$$E[v_j] = \sum_{k=3}^{9} [v_k(t-1) + e_k(t-1) \times w_k + m_k(t)] \times d_{k,j} \tag{3.13}$$

Once the expected total number of vacancies that will occur in each category j is known, it is easy to forecast personnel movements in the system using the $s_{i,j}$ values of the transition rate matrix. Since the $s_{i,j}$ values represent the proportion of vacancies in paygrade category i filled by personnel from paygrade category j, the following equations for the number of promotions, demotions and recruitment can be used:

$$PROM_{i,i+1} = s_{i+1,i} \times \sum_{k=3}^{9} [v_k(t-1) + e_k(t-1) \times w_k + m_k(t)] \times d_{k,i+1} \tag{3.14}$$

for the number of promotions from paygrade i to paygrade i+1,

$$DEM_{i,i-1} = s_{i-1,i} \times \sum_{k=3}^{9} [v_k(t-1) + e_k(t-1) \times w_k + m_k(t)] \times d_{k,i-1} \tag{3.15}$$

for the number of demotions from paygrade i to paygrade i-1, and

$$REC_j = r_j \times \sum_{k=3}^{9} [v_k(t-1) + e_k(t-1) \times w_k + m_k(t)] \times d_{k,j} \qquad (3.16)$$

for the number of recruits to paygrade j.

C. ESTIMATION OF TRANSITION RATE MATRIX S

The transition rate matrix is an integral part of the vacancy model in forecasting future personnel movements. Its non-zero elements $s_{i,i+1}$, $s_{i,i-1}$, and the r_i values will determine how the vacancy model fills vacancies in each paygrade category. Making the assumption that future personnel movements will behave similarly to past movements, these elements can be based on historical data. The values for $s_{i-1,i}$, $s_{i+1,i}$ and r_i in each paygrade i can be estimated as a proportion of each of the terms $PROM_i$, DEM_i, and REC_i, to the sum of all three as derived from historical data. Thus

$$s_{i,i-1} = \frac{PROM_i}{PROM_i + DEM_i + REC_i}, \qquad (3.17)$$

$$s_{i,i+1} = \frac{DEM_i}{PROM_i + DEM_i + REC_i}, \qquad (3.18)$$

and

$$r_i = \frac{REC_i}{PROM_i + DEM_i + REC_i} = 1 - s_{i,i+1} - s_{i,i-1} \qquad (3.19)$$

for all paygrades i.

Eight years of data (1984 to 1991) are available for determination of $PROM_i$, DEM_i, and REC_i values. When aggregated for the entire eight year period, an average value is obtained for each of the estimated rates. This method is suggested by Bartholomew [Ref. 1:p. 113] when the rates are assumed to be the same over the entire period of time. This means we first compute

$$PROM_i = \sum_{yr} PROM_i(yr) \ , \tag{3.20}$$

$$DEM_i = \sum_{yr} DEM_i(yr) \ , \tag{3.21}$$

and

$$REC_i = \sum_{yr} REC_i(yr) \tag{3.22}$$

where the summations are for yr = 1984 ,..., 1991 in each paygrade i.

Table 1 shows the results of computing these aggregate values of $PROM_i$, DEM_i, and REC_i, as well as the $s_{i,j}$ and r_i values which may be directly inserted into the S matrix and $\underline{r}$ vector of the vacancy model.

TABLE 1: ESTIMATED TRANSITION RATES

$PAYGRADE_i$	$PROM_i$	DEM_i	REC_i	$s_{i,i-1}$	$s_{i,i+1}$	r_i
E2/3	0	71	277	0.000	0.204	0.796
E4	176	40	3678	0.045	0.010	0.945
E5	1869	24	159	0.911	0.012	0.077
E6	1027	8	19	0.974	0.008	0.018
E7	692	0	7	0.990	0.000	0.010
E8	146	0	1	0.993	0.000	0.007
E9	50	0	0	1.000	0.000	0.000

D. DETERMINATION OF ATTRITION RATES

Attrition rates can easily be estimated from census transitional data by the formula

$$w_i = \frac{SEP_i}{TOT_i} \qquad \textbf{(3.23)}$$

where SEP_i is the number of separations among personnel who were in paygrade i at the beginning of the year and TOT_i is the beginning of the year personnel inventory in paygrade i.

Making the assumption that attrition rates remain constant from year to year would allow estimating future attrition rates based on historical rates, assuming the latter were stable during the past. However this would not be a valid assumption here as can be seen for paygrades E7, E8, and E9 in Figure 1. The attrition rates for E7 appear to remain fairly stable for the years 1984 through 1989, but jump in value for 1990 and 1991 indicating possibly that future attrition will also be higher. The attrition rates in the E8 and E9 paygrades seem to be less predictable, as can be seen by the sporadic ups and downs over the 1984 through 1991 period. This seems to be the norm as the other paygrade attrition rates also tend to fluctuate up and down. Therefore it might not be prudent to base future attrition solely on historical data.

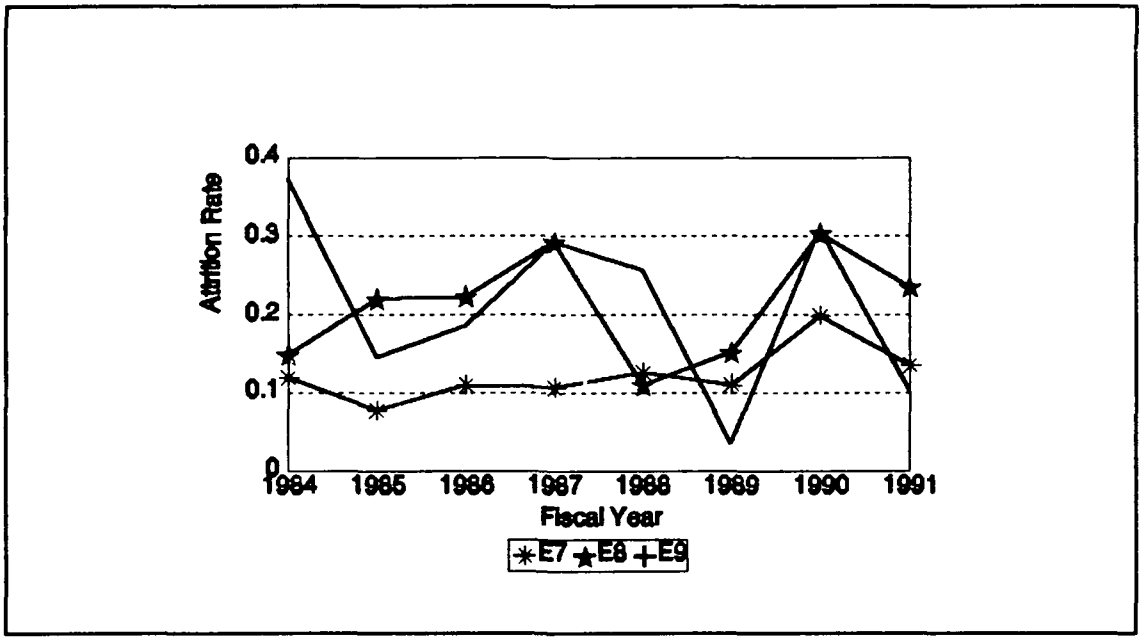

Figure 1: Annual Attrition Rates For E7, E8, and E9

Regression analysis, trend analysis, and survival analysis techniques were all applied to the historical data to determine a better means of estimating future attrition resulting in little success.

Since one of the intents in the use of this model is to apply it to any Coast Guard rating, it is necessary to use a procedure for estimating attrition rates that will be acceptable for any rating model. It was decided that the best method for providing the model with attrition rates was to allow the user to set rates based on existing rates and any advance information available about future rates. This allows the user flexibility in the use of the model by running it with different attrition values to see the results which may occur.

E. ESTIMATION OF TIME IN SERVICE TO ADVANCEMENT (TISADV)

One of the objectives of this thesis is to estimate the time in service of those promoted, called Time in Service to Advancement (TISADV). These values are used as a measurement of how career opportunities change in the Coast Guard. The longer the time to advancement (i.e. larger TISADV), the less opportunity for advancement to higher paygrades during one's career.

Again, historical data are relied upon to estimate future TISADV values. We see from the Time in Service (TIS) tables in Appendix A that both inventory TIS values and promotees' TIS values both tend to be increasing during the years 1984 to 1991 as illustrated by Figure 2 for the E4, E5, and E6 paygrades and by Figure 3 for the E5, E6, and E7 paygrades. These figures tend to suggest there might be a linear relationship between beginning of year inventory

mean Time in Service and promotees' mean Time in Service to Advancement. This seems to be true for the middle paygrades which can be seen by a plot of E5 promotees mean TISADV against E4 inventory mean TIS in Figure 4.

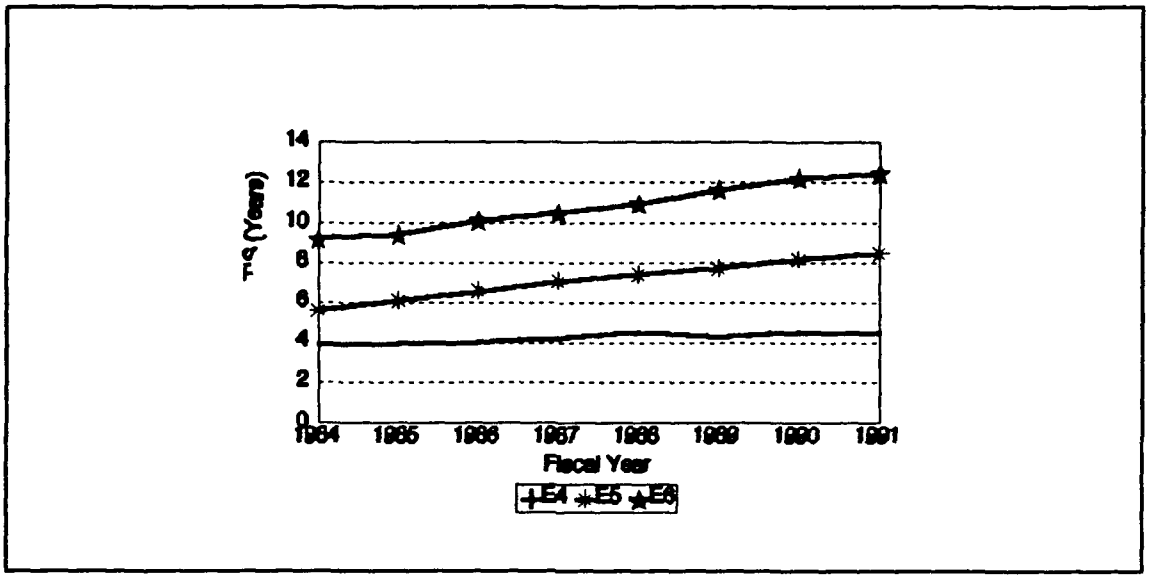

Figure 2: Time in Service for E4, E5, and E6 Beginning of Year Inventories

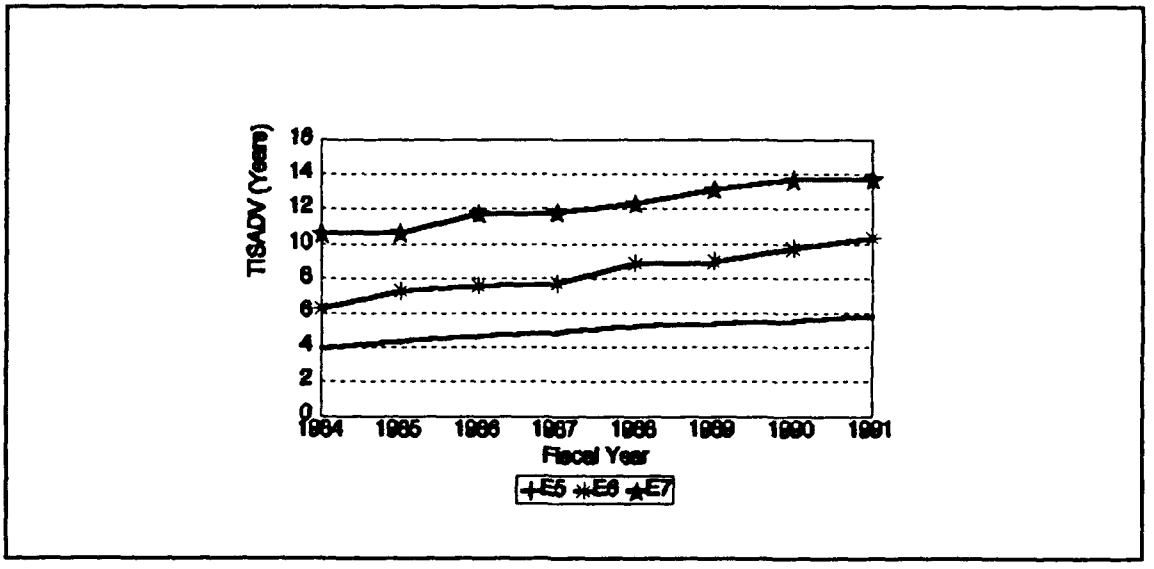

Figure 3: TISADV for E5, E6, and E7 Promotees

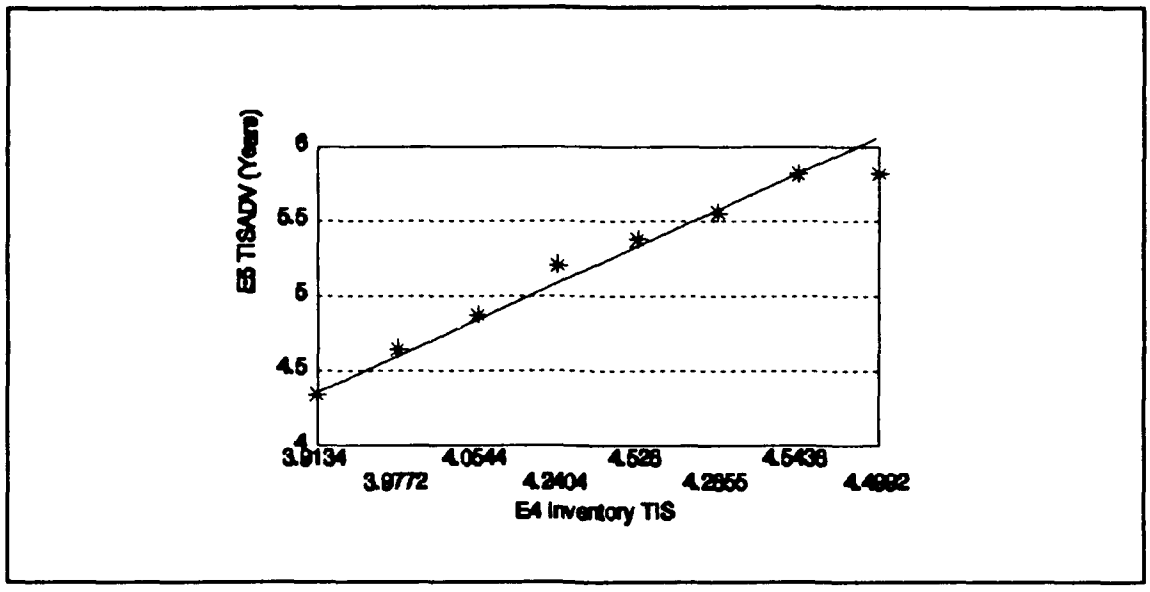

Figure 4: E5 TISADV versus E4 Inventory TIS

When linear regression was applied to the data in Figure 4, an r-squared value of 0.87 was found. This indicates that 87 percent of the variability in the dependent variable, E5 *mean* TISADV, can be explained by the independent variable, E4 inventory mean TIS. This high r-squared may be significant enough to allow for prediction of future TISADV values based on beginning of year inventory TIS values. Using regression, the TISADV for paygrade i would be found by

$$TISADV_i = A + B \times TIS_{i-1} \qquad (3.24)$$

where 'A' is the intercept and 'B' the slope of the regression line. Linear regression, however, may not always be appropriate as indicated by the data. A range of r-squared values from 0.02 to 0.99 were found when trying to fit lines to E4 through E9 TISADV values.

It is necessary to develop a method of predicting future TISADV that will work for all rates and paygrades in order for the model to be versatile. An alternative method to linear regression is to use ratios of promotees' mean TISADV to beginning of year inventory mean TIS based on weighted historical data. Weights would be assigned by both the number of promotees in a year and a yearly weight which could be chosen by the user. This would result in a multiplicative factor C_i which could be used to predict promotees' mean TISADV as shown by the formula:

$$TISADV_i = C_i \times TIS_{i-1} \tag{3.25}$$

The C_i values can be estimated as

$$C_i = \frac{\textit{Weighted Average } TISADV_i}{\textit{Weighted Average } TIS_{i-1}} \tag{3.26}$$

where weights are assigned by year and number of promotees in the numerator and by year and number in inventory for the denominator. This leads to the following equations:

$$\textit{Weighted Avg } TISADV_i = \frac{\sum_{yr} wt(yr) \times TISADV_i(yr) \times PROM_i(yr)}{\sum_{yr} wt(yr) \times PROM_i(yr)} \tag{3.27}$$

for the numerator and

$$\textit{Weighted Avg } TIS_{i-1} = \frac{\sum_{yr} wt(yr) \times TIS_{i-1}(yr) \times TOT_{i-1}(yr)}{\sum_{yr} wt(yr) \times TOT_{i-1}(yr)} \qquad (3.28)$$

for the denominator where wt(yr) is the weight assigned by the user for each year of data. One would expect the near future to behave similarly to the most recent past. Therefore in assigning yearly weights, it would be most logical to give the highest weight to the most recent data and the lower weights to the earlier years of data.

An example of computing a 'C' multiplier is shown below for promotions to E8 (i=8). As can be seen by Figure 5, linear regression does not appear to adequately explain the variation in $TISADV_8$ by TIS_7. In fact, the r-squared value is 0.55. For that reason, the alternative method of the 'C' multiplier is used.

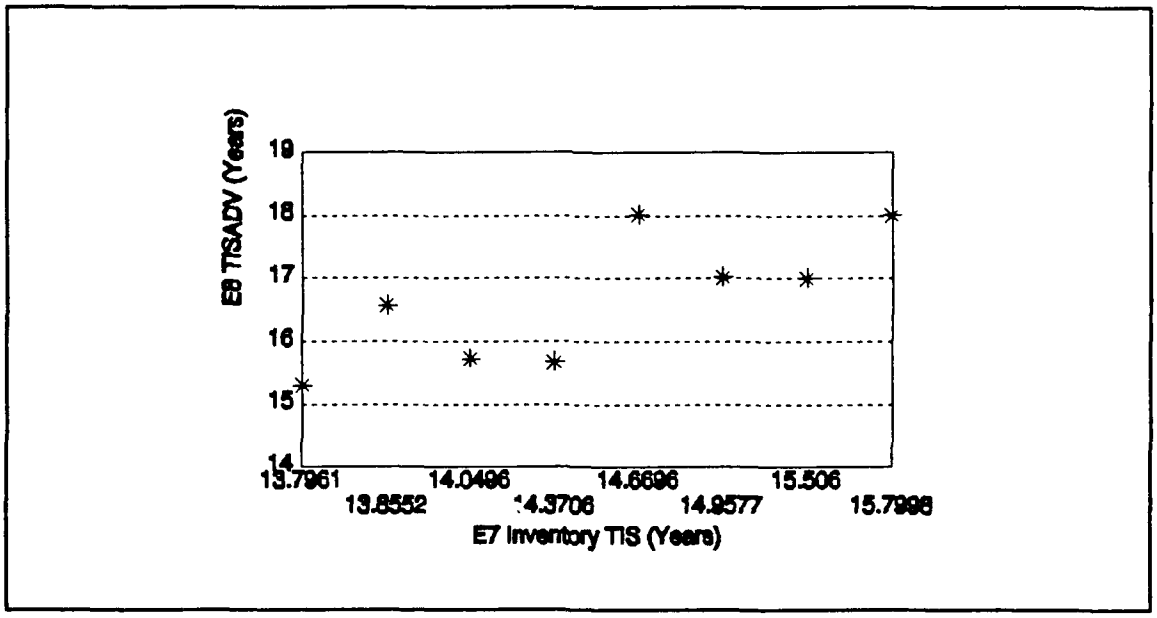

Figure 5: $TISADV_8$ versus TIS_7

When the data are weighted by year and number of personnel in the category, the following values are found:

- Weighted Average $TISADV_8$ = 17.046
- Weighted Average TIS_7 = 14.981

This results in C_8 = 1.138.

This C_8 value can now be used to predict future $TISADV_8$ by the formula:

$$TISADV_8 = 1.138 \times TIS_7 \qquad (3.29)$$

The model is constructed such that the user has the ability to decide as to which method, regression or 'C' multiplier, to use by inputting a minimum acceptable r-squared allowed for the regression method. If a value of 0.8 is entered, then regression will be used when the r-squared value in the paygrade data is greater or equal to 0.8 and the 'C' multiplier will be used when the r-squared value in the paygrade data is less than 0.8.

F. ESTIMATION OF FUTURE YEARS' INVENTORY MEAN TIME IN SERVICE

Since estimating promotees mean TISADV requires a beginning of year inventory mean TIS, it is necessary to estimate these parameters for years two through five in the model. This requires use of all the previous years' inventories and flows to compute a new beginning of year inventory and the corresponding mean TIS value for each of years two through five. Estimating beginning of year inventory mean TIS requires two steps.

1. Estimating Beginning of Year Inventories

This requires using the previous years' personnel inventory as starting values, then subtracting personnel flows out and adding personnel flows in to get the new beginning of year personnel inventories for the new year. Flows out result from promotions out of the paygrade, demotions out of the paygrade, and attrition from the paygrade, whereas flows in are due to promotions into the paygrade, demotions into the paygrade, and recruitment to the paygrade. This can be expressed as

$$TOT_i(yr+1) = TOT_i(yr) - PROM_{i+1}(yr) - DEM_{i-1}(yr) - SEP_i(yr) + PROM_i(yr) + DEM_i(yr) + REC_i(yr) \quad (3.30)$$

for all i = E3 through E9. Note for i = E3, there are no demotions to a lower paygrade, so $DEM_{i-1}(yr)$ is always zero. Similarly for i = E9, there are no promotions out to a higher paygrade, so $PROM_{i+1}(yr)$ is also always zero.

2. Estimating Beginning of Year Mean TIS

The new beginning of year inventories were found in Equation 3.30 by taking the previous year's inventory, subtracting all flows out of the paygrade category and adding all flows in to the paygrade category. The mean Times in Service (TIS) of beginning year inventories are computed in a similar manner. They may be found as the weighted average TIS of those personnel remaining in the paygrade at the end of the current year (i.e. beginning of year inventory minus personnel flows out) which are then aged by one year, and the TIS of those entering the paygrade category from elsewhere. Using the beginning of

year mean TIS of paygrade i, $TIS_i(yr)$, the next beginning of year mean TIS of paygrade i, $TIS_i(yr+1)$, may be expressed as:

$$TIS_i(yr+1) = \frac{ENDTOT_i(yr) \times (ENDTIS_i + 1) + FINTIS_i}{ENDTOT_i(yr) + MOVEIN_i(yr)} \qquad (3.31)$$

where

- $ENDTOT_i(yr)$ represents the number of personnel remaining in paygrade i after subtracting personnel flows out:

$$ENDTOT_i(yr) = TOT_i(yr) - PROM_{i+1}(yr) - DEM_{i-1}(yr) - SEP_i(yr) \qquad (3.32)$$

- $ENDTIS_i$ represents the end of year mean TIS of those personnel remaining in paygrade i at the end of the year yr and is computed by the formula:

$$ENDTIS_i(yr) = \frac{TOT_i(yr) \times TIS_i - OUTTIS_i}{ENDTOT_i(yr)} \qquad (3.33)$$

where

$$OUTTIS_i = PROM_{i+1}(yr) \times TISADV_{i+1} + DEM_{i-1}(yr) \times TISDEM_{i-1} + SEP_i(yr) \times TISSEP_i \qquad (3.34)$$

with $TISDEM_{i-1}$ being the mean TIS of personnel demoted to paygrade i-1, and $TISSEP_i$ the mean TIS of personnel attrited from paygrade i.

- $FINTIS_i$ represents the mean TIS of personnel who moved into paygrade i during the year; i.e.

$$FINTIS_i = PROM_i(yr) \times TISADV_i + DEM_i(yr) \times TISDEM_i + REC_i(yr) \times TISREC_i \qquad (3.35)$$

where $TISREC_i$ is the mean TIS of personnel recruited into paygrade i.

- $MOVEIN_i(yr)$ represents the number of personnel who moved into paygrade i during the year. It is the sum of promotions in, demotions in, and recruitment into paygrade i:

$$MOVEIN_i(yr) = PROM_i(yr) + DEM_i(yr) + REC_i(yr) \qquad (3.36)$$

Notice that estimation of new beginning of year inventory mean TIS values requires estimation of not only $TISADV_i$, but also $TISSEP_i$, $TISDEM_i$, and $TISREC_i$. These values will be estimated in the same manner as estimating $TISADV_i$ described in Section D of Chapter II. Regression will be used when appropriate and the 'C' multiplier will be used otherwise.

Some flows of personnel are very small (i.e. less than 20). This is usually the situation for demotions and in recruitment to the higher paygrades. For these cases, the model will automatically use the 'C' multiplier for estimating the mean TIS values, because there would be a lack of statistical stability in the use of regression.

G. MODEL CONSTRAINTS

To make the model more realistic to the actual manpower system, two constraints are added to the model.

1. Promotion Rates

Each year, promotion rates will differ from the previous year. To avoid wild deviations from year to year, the user may input a plus and minus

maximum change in promotion rate allowed. For example, if the previous years promotion rate was 0.3 and the user indicated a plus 0.05 and minus 0.1 permissible change in rate, next year's promotion rate would be constrained between 0.20 and 0.35. These plus and minus values are entered by the user for each paygrade allowing for different constraints to exist in each paygrade.

2. Recruitment

A majority of recruitment comes from 'A' school graduates as was previously discussed in Chapter I. The school itself has limitations on how many graduates it can produce in a year, therefore the model requires a constraint of a maximum number of recruits allowed. On the other hand, to keep the school operating and the instructors well trained, there is also a minimum number of graduates desired. Thus a constraint of a minimum recruitment number is needed. This minimum and maximum recruitment will only affect recruitment into the E2/3 and E4 paygrades since this is where all 'A' school graduates enter the MK system. Therefore the minimum and maximum recruitment constraint will be based on the sum of the recruitment into these two paygrades. If the constraint is used by the model, the proportion that goes to E2/3 and E4 will be determined by the proportion used by the unconstrained model (e.g. if 70% of the sum of E2/3 and E4 recruits are in E4 when not constrained by the model, then 70% of the constrained recruits will also be in E4).

Placing the promotion and recruitment constraints in the model will cause differences between the end of year inventories and the end of year number of billets. These differences in each paygrade may exist as positive or negative vacancies where positive vacancies represents fewer personnel than billets and negative vacancies represents more personnel than billets. When the model is not constrained, there will be zero vacancies in each paygrade at the end of a period. In the validation of the model as shown in Appendix C (page 103), it is seen that end of year vacancies, as computed by one iteration of the vacancy model, are given by v(t) = (-4,4,15,-15,0,1,-1) for paygrades E2/3, E4 through E9. Note the paired numbers of opposite signs. In fact, the -4 and 4 number of vacancies for paygrades E2/3 and E4 is a result of reaching the maximum number of promotions to E4. Because of the promotion constraint, four fewer personnel were promoted than desired by the vacancy model causing four positive vacancies in E4 and four excess personnel (negative vacancies) in E2/3. The same is true for the 15 and -15 vacancies in the E5 and E6 paygrades and for the 1 and -1 vacancies in the E8 and E9 paygrades where the minimum constraints were required in both paygrades E6 and E9.

These deviations between the number of inventories and the number of billets may be reduced by recomputing the vacancy model multiple times for the same year. To accomplish this, each new iteration of the vacancy model must have the previous unconstrained vacancies added to Equation 3.11. For the example cited in the preceding paragraph, the vector (-4,0,15,0,0,1,0) is added

to Equation 3.11 and a second iteration of the vacancy model is computed. This results in a new vacancy vector of (-1,1,-1,-14,0,0,1,) as seen on page 101 of Appendix C. Several things happened in the second iteration of the vacancy model.

- The one vacancy in paygrade E8 was filled by an additional promotion.
- The -15 vacancies that previously existed in the E6 category is now reduced to -14 vacancies, since the additional promotion from E8 to E9 also caused an additional promotion from E7 to E8, and from E6 to E7.
- The 15 vacancies in paygrade E5 is now reduced to -1 vacancy by having 15 additional promotions and one additional recruit to the paygrade E5. The -1 results from the need for the additional promotion caused by the promotion constraint in paygrade E9 and the inability to promote that one additional person because of the E6 constraint.
- The four vacancies in paygrade E4 is now reduced to one vacancy by additional recruitment. The one vacancy exists because of constraints in the higher paygrades.
- The negative four vacancies in paygrade E2/3 is reduced to -1 vacancy by less recruitment. The -1 vacancy here also exists because of constraints in the higher paygrades.

By introducing the additional vacancies in the vacancy model, it is seen that those vacancies may be filled by the unconstrained paygrade categories. However, constraints in the higher paygrade categories may cause positive or

negative vacancies to still exist after the second iteration as can be seen in the example for paygrades E2/3, E4, and E5. One additional iteration of the vacancy model will reduce these to zero resulting in a final vacancy vector for the first year of forecasting as (0,0,0,-14,0,0,1). The only non-zero vacancies are in the two constrained paygrade categories, E6 and E9.

It is conceivable that seven iterations (number of categories) of the vacancy model would be needed in one year to completely eliminate all unconstrained vacancies. This would be the case where only paygrade E9 would be constrained in the first iteration, paygrades E8 and E9 both constrained in the second iteration, paygrades E7, E8, and E9 in the third, and so on. However, since this would be an extremely rare situation, the Coast Guard Rating Forecast Model is programmed to conduct only four iterations of the vacancy model for each year. This slows the automatic calculation of the model to a small extent, but as changes in input values are entered, the model re-calculation is still fairly instantaneous on an IBM 486 machine.

IV. ANALYSIS OF RESULTS

A. MODEL VALIDATION

The Coast Guard Rating Forecast Model was developed using Markov theory and the estimation of certain model parameters from historical data. This required several assumptions to be made. Those assumptions are:

- the transition probabilities and Time in Service values are unchanged over time,
- the transition probabilities are the same for all individuals in a paygrade, and
- personnel behave independently of one another.

The first assumption was needed in order to use historical data for estimation of the transition matrix and for calculation of future Time in Service values. The second and third assumptions are equally important and were needed to base the vacancy model on Markov theory. Whether these assumptions are true or not, the model can be considered valid if the forecasted values obtained by the model match the actual values with sufficient degree of accuracy.

A maximum of eight years of historical data is allowed in the model, but a minimum of four years can be used with some statistical accuracy. Bartholomew [Ref. 1: p. 115] suggests using the first part of historical data to predict the later part, thereby establishing a method of model validation. This was done here for the MK rating using historical data from the years 1984 to

1988 to estimate the transition matrix and TIS parameters of the model for the purpose of predicting personnel inventories and flows for the years 1989 through 1993. Since historical data are available through the year 1991, the first three years of the model's forecast (1989 - 1991) can be compared to the actual values.

1. Analysis of End of Year Inventories

Table 2 provides the end of year inventories for fiscal years 1989 through 1991 in each paygrade as was predicted by the model, displayed next to what was actually observed for that year and paygrade. As can be seen, the

TABLE 2: PREDICTED AND OBSERVED END OF YEAR INVENTORIES

Paygrade	1989		1990		1991	
	Predict	Observe	Predict	Observe	Predict	Observe
E-2/3	73	10	73	29	66	193
E-4	1098	1136	1096	1033	1127	1097
E-5	990	985	974	953	992	961
E-6	841	823	821	815	822	826
E-7	537	536	508	520	521	518
E-8	54	56	59	55	59	61
E-9	30	29	26	29	31	31
Total	3623	3575	3557	3434	3618	3687

predicted and observed inventories for each paygrade are actually quite close in value with the exception of the E2/3 paygrade. Viewing the predicted values

in terms of percent errors of the observed values as computed by the equation

$$\%ERROR = \frac{Predicted - Observed}{Observed} \times 100\% \qquad (4.1)$$

it is possible to evaluate the accuracy of the model forecasts. Table 3 shows the percent error of predicted inventory values for each paygrade in the years 1989 through 1991. It is seen that in paygrades E4 through E9 the predicted values are within plus and minus 4 percent except for the fiscal year 1990 values where paygrades E4, E8, and E9 have percent errors as high as 10.3 percent. However, problems seem to exist with the prediction of the E2/3

TABLE 3: PERCENT ERROR FOR PREDICTED 1989 - 1991 INVENTORIES

Paygrade	1989 % Error	1990 % Error	1991 % Error
E-2/3	630	152	-65.8
E-4	-3.3	6.1	2.7
E-5	0.5	2.2	3.2
E-6	2.2	0.7	0.5
E-7	0.2	1.5	0.6
E-8	-3.6	7.3	-3.3
E-9	3.5	10.3	0
Total	1.3	3.6	-1.9

paygrade inventories. This is only true because the model tends to predict inventories based on the number of required billets. In each year 1989, 1990,

and 1991, the number of required billets was 73, 73, and 67 respectively, which were exactly the numbers of personnel inventories predicted by the model. It is noted that the observed values for 1989, 1990, and 1991 were 21, 10, and 193 respectively. This was significantly lower than the 73 required billets for 1989 and 1990, and was significantly higher than the 67 required billets for 1991. These large differences in observed values and required billets tend to be a result of E2/3 personnel typically not possessing a rating designator. E2/3 personnel may possess a rating designator if they reached that paygraade by:

- getting demoted from E4;
- graduating from "A" school without the proper qualifications to be promoted to E4; or
- obtaining a designator through a "striker" program.

These cases are not the norm. Usually a person obtains a rating designator as an E4. In viewing the historical data for the MK rating, the number of E2/3 MK personnel is on the average only 5.5% of the number of E4 MK personnel. The Coast Guard recognizes there will always be a certain number of designated personnel in the E2/3 paygrades and has established required billets in those paygrades for this reason. But the actual number of E2/3 personnel will not always be the same as the required billets. The reason a big jump in E2/3 MK personnel occurred in 1991 (29 to 193) was because of the large number of "A" school graduates during 1991 that didn't make E4. These situations can happen and are difficult to predict, therefore are not accounted for in the model.

These results presented in Tables 2 and 3 seem quite good considering that observed inventories typically are not equivalent to end of year number of billets, whereas the vacancy model attempts to have billets equal personnel for each year and would in fact have them exactly the same except for the recruitment and promotions constraints being included in the model.

2. Analysis of Promotions

The model calculates the number of promotions from the predicted number of vacancies using the estimated transition matrix. Table 4 shows the comparison of predicted promotions to observed promotions. It appears there are some significant differences in the annual number of promotions to each paygrade. A better representation of these differences can be seen in Table 5

TABLE 4: PREDICTED AND OBSERVED PROMOTIONS

Paygrade	1989		1990		1991	
	Predict	Observe	Predict	Observe	Predict	Observe
E-4	13	14	42	0	38	19
E-5	219	203	211	235	214	195
E-6	99	82	133	159	131	128
E-7	63	63	104	118	103	92
E-8	7	8	26	25	22	24
E-9	3	2	5	9	8	5
Total	404	372	521	546	516	463

where the percent error of the predicted number of promotions to the observed number of promotions is displayed. It is seen in many cases, the percent error is quite high (>10%). However in looking at the total number of promotions in each year, the total percent errors are smaller (8.6, -4.6 and 11.4 for 1989, 1990, and 1991 respectively). Also, in taking a total number of promotions for the three year period and then calculating the percent error for this three year total, it is seen that the paygrade three year average errors all lie between -3.5 and 1.7 percent with the exception of E4. These paygrade three year average percent errors tends to show considerable improvement over the annual paygrade percent errors. This tendency for statistical stability over the three year period is a result of averaging out the variability that is observed in the annual promotion values. The lack of stability in the annual data was one of the

TABLE 5: PERCENT ERROR FOR PREDICTED 1989 - 1991 PROMOTIONS

Paygrade	1989 % Error	1990 % Error	1991 % Error	Avg % Error
E-4	-7.1	N/A	100	181.8
E-5	7.9	-10.2	9.7	1.7
E-6	20.7	-16.4	2.3	-1.6
E-7	0	-11.8	11.9	-1.1
E-8	-12.5	4	-8.3	-3.5
E-9	50	-44.4	60	0
Total	8.6	-4.6	11.4	4.3

problems that was found in the data analysis of Chapter II. To limit these effects, the model uses average values over the range of historical data entered. Since this particular validation of the model used four years of data, future promotions are determined from the four year weighted averages. (See Chapter II for further details.) Because of the data variability in the observed values, it may be expected that the model predictions will have smaller percent errors when compared to average observed values.

The large average percent error for E4 tends to suggest some difficulties in prediction of E4 promotions. However, in analyzing the model process in relation to observed values, it is seen the model tends to correct the problem of 222 excess E4 personnel (-222 vacancies at beginning of year 1989) in the first year of the prediction whereas the observed values were not able to completely correct the situation during the three year period. In fact, the observed values over-corrected resulting in 29 vacancies in the E4 paygrade at the end of fiscal year 1991. This difference in the model's correction process and the correction which took place in the observed values accounts for the large E4 percent error.

The differences in the predicted E2/3 inventories and the observed E2/3 inventories also helps to explain the large average percent error for promotions to E4. The average predicted E2/3 inventory for beginning of years 1989 - 1991 is 56 compared to the average observed inventory for the same period of 20. Since the predicted average E2/3 inventory is almost three times

as much as the actual inventory, the average predicted promotions is expected to be three times that of the average observed promotions (31 versus 11).

3. Analysis of Recruitment

Predicted recruitment was determined by the model based on estimated transition rates of vacancies out of the system and the predicted number of vacancies. Table 6 compares the model's predicted recruitment to the observed recruitment for the years 1989 through 1991 and Table 7 displays the corresponding percent errors. It appears there is some discrepancy between predicted recruitment and observed recruitment especially when viewing the percent errors. However it should be noted that except for the E4 paygrade, all other paygrades have small recruitment numbers, and therefore the percent errors in these paygrades are not particularly meaningful.

TABLE 6: PREDICTED AND OBSERVED ANNUAL RECRUITMENT

Paygrade	1989		1990		1991	
	Predict	Observe	Predict	Observe	Predict	Observe
E-2/3	55	2	84	22	40	190
E-4	258	272	455	415	450	462
E-5	21	14	20	2	21	24
E-6	2	0	3	1	3	4
E-7	1	1	2	0	2	1
E-8	0	0	0	0	0	0
E-9	0	0	0	0	0	0
Total	337	289	564	440	516	681

TABLE 7: ANNUAL RECRUITMENT PERCENT ERROR

Paygrade	1989 % Error	1990 % Error	1991 % Error	Avg % Error
E-2/3	26500	282	-78.9	-16.4
E-4	-5.1	9.6	-2.6	1.2
E-5	50	900	-12.5	55
E-6	N/A	200	-25	60
E-7	0	N/A	100	150
E-8	0	0	0	0
E-9	0	0	0	0
Total	16.6	26.2	-24.2	0.5

When looking at the total predicted recruitment over the three year (average) period as compared to the total observed recruitment for the same period, the percent error is only 0.5 percent.

In viewing the total recruitment for each year, it is seen the model predicts more recruitment for years 1989 and 1990 and less recruitment for 1991 than what was actually observed. Analyzing each year separately, the differences in 1989 can be contributed to the larger number of E2/3 recruitment needed to fill the 73 required billets whereas in the observed data, those billets are left vacant. Without the E2/3 recruitment, the total percent error for 1989 would be -1.7 percent. For 1990, the model's end year inventory is 3557 (15 vacancies), whereas the observed end of year inventory was 3434 (138

vacancies). The additional 123 vacancies (138 - 15) in observed inventory accounts for the difference of 124 recruits (564 - 440) between predicted and observed recruitment for the year 1990. These 138 observed vacancies at the end of fiscal year 1990 also had an effect on 1991 observed recruitment. Since the year started out with a large number of vacancies, additional recruitment was observed for that year which is the reason for the -24.2 percent error of predicted to observed recruitment. Without those additional observed recruits, the total percent error for 1991 would have been -5.0 percent of the observed recruitment. It is seen these two problems, the E2/3 observed vacancies and the end of 1990 observed total vacancies, resulted in the discrepancies between predicted and observed recruitment.

4. Analysis of Time in Service to Advancement for Promotees

The second objective of this thesis was to predict the mean Time in Service to Advancement (TISADV) of those promoted each year. These values were estimated as a function of beginning of year inventory mean Time in Service by linear regression or by a constant multiplier. (See Chapter III). Table 8 shows the predicted TISADV alongside the observed TISADV for the years 1989 to 1991. The predicted TISADV for 1989 are quite close to the observed values for that year. In fact, the predicted values were within minus seven to plus one percent error from the observed as can be seen by the percent errors in Table 9. Comparing predicted to observed for the year 1990, the error range increases to -12 to plus seven percent of the observed. This increase in error

TABLE 8: PREDICTED AND OBSERVED TISADV FOR PROMOTEES

Paygrade	1989 Predict	1989 Observe	1990 Predict	1990 Observe	1991 Predict	1991 Observe
E-4	3.21	3.45	2.54	N/A	1.25	1.89
E-5	5.35	5.55	5.45	5.81	4.09	5.81
E-6	8.5	9	8.62	9.73	8.71	10.34
E-7	13.2	13.12	13.61	13.69	13.67	13.71
E-8	16.64	17.02	17.05	17	16.82	18.01
E-9	18.86	19.17	19.22	18.06	18.55	19.23

range may be expected, since at the end of the first year, the model must first estimate a new inventory mean TIS value for each paygrade. This is bound to cause greater error in the prediction of TISADV in the second year. This tendency for increased error rates will prevail for each forecasted year out to the fifth year when using the model. This is found to be true in the third year (1991) of the model, where the error percentages range from -34 to zero percent. It is expected that improvement will be made in the accuracy of the TISADV estimation when eight years of historical data are used by the model versus the currently used four years in this run. The additional data should help to eliminate any major deviations that may have occurred in the data due to exogenous conditions.

TABLE 9: TISADV FOR PROMOTEES PERCENT ERROR

Paygrade	1989 % Error	1990 % Error	1991 % Error
E-4	-7	N/A	-33.8
E-5	-3.6	-6.2	-29.6
E-6	-5.6	-11.4	-15.8
E-7	0.6	-0.6	-0.3
E-8	-2.2	0.3	-6.6
E-9	-1.6	6.4	-3.5

B. MODEL RUN FOR 1993 THROUGH 1997

The 1989 model run appears to validate the model. Since the primary intent for the use of this Coast Guard Rating Forecast Model is to examine end of fiscal year changes in the number of required billets for a specific rating as forecasted in the Manning Requirements Document (MANREQ), the model is run for the MK rating starting with fiscal year 1993. The fiscal year 1993 MANREQ was released in October 1992 (beginning of fiscal year 1993), about the same time that research for this thesis was started. Therefore it is the most current MANREQ document in existence and its values for the end of fiscal year 1993 projected number of billets are used as input to the model. All other input parameters (i.e. beginning of year inventories and billets, estimated attrition

rates, projected five year required billet strengths, and constraint requirements) were provided by the Workforce Planning staff at Coast Guard Headquarters (G-PWP).

Eight years of historical data (1984 - 1991) was used to estimate the parameters for the 1993 MK model run. Note that the most current historical data available for the 1993 model run were the 1991 data, because 1992 data was not completely available at the beginning of fiscal year 1993. It will always be the case that the previous year's historical information will not be available for use in the model run. Therefore, the model is designed to run without that data.

Appendix D consists of the input and output pages for the 1993 to 1997 MK model run. These pages in Appendix D is what a model user would usually want to see. All the other model pages seen in Appendix C are calculation pages and would only be needed by the user if he/she desired to study the process used in the model or to analyze further the results that are provided in the annual output pages of Appendix D. These input and output pages are arranged in the spreadsheet downward from the beginning of the front page. Therefore to see the additional computation pages, it would be necessary to scroll across the computer screen to the additional columns in the spreadsheet.

Note, since the vacancy model is driven by attrition, the accuracy of the five year forecast will depend primarily on the estimated attrition rates that are entered. It is important in future runs of the model that the user exhibit

diligence in estimating these rates, in order for the model to forecast with some degree of accuracy, future inventories, personnel flows, and mean time in service values.

V. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

This thesis developed and implemented a "Coast Guard Rating Forecast Model" for the Machinist Mate (MK) rating that forecasts future end of fiscal year inventories, annual flows of personnel, and mean Times in Service to Advancement (TISADV) for five consecutive years. One of the primary uses of this model is to assess proposed changes in the billet workforce structure as found in the Manning Requirements document (MANREQ). This MANREQ document, issued at the beginning of a fiscal year, predicts the Coast Guard's manpower requirements for the end of the fiscal year. This prediction of billet requirements can then be used as input into the model to determine how these changes will affect end of fiscal year and future years' inventories and TISADV values.

The two primary objectives raised in Chapter I were realized by this thesis.

1. Forecast Future Rating Structure

The objective was to construct a mathematical model that would forecast a future rating force structure, given the current workforce billet requirements and known personnel inventory values. The model was also to specify promotion rates, attrition rates, and recruitment levels for the current fiscal year and the following four years. The Coast Guard Rating Forecast

Model processes available historical data and user input to forecast future inventories and personnel flows for five, one year periods.

2. Forecast Time in Service to Advancement

This objective required the model to estimate the Time in Service to Advancement (TISADV) for personnel in each paygrade and for each year of the model forecast to see how changes in personnel inventories and flows would affect these values. The Coast Guard Rating Forecast Model provides these values to the user along with Time in Service (TIS) values of those attriting, TIS values of those demoted, and TIS values of those recruited. These forecasted TIS values should allow the Coast Guard to track changes in career opportunities and attempt to establish certain optimum TISADV values that are beneficial to the personnel.

The model may have other direct benefits which can be used by workforce planners. For example, the forecasted recruitment flows for each year may be used to better estimate annual 'A' school requirements and class convening dates. Promotion flows may establish reliable promotion cut-off points for semi-annual promotion lists. Promotion constraints can determine whether a specific rating should allow direct enlistment or be closed to enlistment from other services. This may increase or decrease promotions from within the rating, and change a constrained value in the model to a more optimum (near zero) end of year vacancy vector. Other possible uses may be explored as the model gets used in forecasting for the rating manpower systems.

B. RECOMMENDATIONS

The accuracy of the model's forecasts depends on the input parameters and historical data. Therefore it is essential that these values are determined through reliable methods.

1. Input Parameters

The primary driving force of the model comes from attrition. It is critical these values be as accurate as possible, for they will have the largest effect on forecast accuracy. A significant amount of time was spent by the author attempting to establish a completely reliable means of forecasting accurate attrition rates, with no success. Other thesis reports were viewed, namely Bardo [Ref. 3], Rodgers [Ref. 4], Blakemore [Ref. 5], in attempts to find an acceptable method for attrition prediction. However, it was determined the best method for this model is to allow the user to estimate attrition rates based on current rates and predicted trends. Improvement in the prediction of attrition rates may be made through further research in this area.

The estimation in TIS values requires the use of a multiplier when regression is not used. These multiplier values, C_i (See Section E of Chapter III), require weighted historical data where weights are assigned by the user for each year of data. The weights assigned may be based on the age of the data and its reliability. These weights are somewhat subjective, and it may be found that a certain combination of weights may give better results than another set of weights. It may be possible to establish a procedure or produce a computer

program that may find the optimum set of weights to use based on historical data and past results and then use these weights for future runs of the model. Of course these optimum weights may change for each set of data, but finding a suitable methodology could give some insight as to possible magnitudes or ranges of values to use.

2. Historical Data Reliability

The importance of accurate historical data has already been mentioned in connection with the TIS multipliers. It is also important in determining historical inventories and personnel flows for the estimation of the transition matrix of the model. The author had some difficulty in obtaining "good" historical data in that certain records and data fields were either missing or had improper entries. Therefore, it was necessary to "clean" the data files by finding proper values when possible or by making assumptions as to the cause of the error. Special regard should be used in the processing of data records in the attempt to provide reliable historical data for analysis use. It is also noted that only one source for historical data was used in this thesis. It appears there are many different historical data files available which seems to indicate some duplication of effort. One set of historical data can provide all the necessary information needed if it is complete and accurate and serves the needs of everyone who may need such data.

APPENDIX A
HISTORICAL DATA

Page 7 ANNUAL DATA

VALUES ARE # IN PAYGRADE AT BEGINNING OF YEAR (INVENTORIES)

YEAR by PAYGRADE

YEAR	Count	PAYGRADE E-3 3.00	E-4 4.00	E-5 5.00	E-6 6.00	E-7 7.00	E-8 8.00	E-9 9.00	Row Total
84.00		187	1157	930	885	493	67	43	3762
									11.3
85.00		59	1250	936	928	512	68	41	3794
									11.4
86.00		30	1274	986	927	500	67	43	3827
									11.5
87.00		35	1310	879	925	525	58	41	3773
									11.4
88.00		24	1207	894	894	546	54	35	3654
									11.0
89.00		21	1264	954	856	541	59	28	3723
									11.2
90.00		10	1136	985	823	536	56	29	3575
									10.8
91.00		29	1033	953	815	520	55	29	3434
									10.3
92.00		193	1097	961	826	518	61	31	3687
									11.1
Column Total		588	10728	8478	7879	4691	545	320	33229
		1.8	32.3	25.5	23.7	14.1	1.6	1.0	100.0

VALUES ARE # RECRUITED DURING THAT FY.

YEAR by PAYGRADE

YEAR	Count	PAYGRADE E-3 3.00	E-4 4.00	E-5 5.00	E-6 6.00	E-7 7.00	E-8 8.00	Row Total
	84.00	17	555	39	9	3	1	624 15.1
	85.00	9	526	23	2	1		561 13.5
	86.00	21	497	3	2	1		524 12.7
	87.00	2	368	31				401 9.7
	88.00	14	583	23	1			621 15.0
	89.00	2	272	14		1		289 7.0
	90.00	22	415	2	1			440 10.6
	91.00	190	462	24	4	1		681 16.4
	Column Total	277 6.7	3678 88.8	159 3.8	19 .5	7 .2	1 .0	4141 100.0

Page 13 SINGLE ADVANCEMENTS IN ONE YEAR
7/18/93
VALUES ARE # PROMOTED TO THAT PG DURING THE FY.

YEAR by PAYGRADE

YEAR	Count	PAYGRADE E-4 4.00	E-5 5.00	E-6 6.00	E-7 7.00	E-8 8.00	E-9 9.00	Row Total
84.00		86	279	182	101	23	12	683 17.2
85.00		19	273	99	51	22	8	472 11.9
86.00		12	201	154	93	12	6	478 12.1
87.00		20	239	135	96	19	6	515 13.0
88.00		6	244	88	78	13	2	431 10.9
89.00		14	203	82	63	8	2	372 9.4
90.00			235	159	118	25	9	546 13.8
91.00		19	195	128	92	24	5	463 11.7
Column Total		176 4.4	1869 47.2	1027 25.9	692 17.5	146 3.7	50 1.3	3960 100.0

Page 16 TWO ADVANCEMENTS IN ONE YEAR
7/18/93
VALUES ARE # PROMOTED TO THAT PG DURING THE FY.

YEAR by PAYGRADE

YEAR	Count	PAYGRADE E-5 5.00	E-6 6.00	E-9 9.00	Row Total
	84.00	8	5	2	15 71.4
	86.00		3		3 14.3
	87.00	2			2 9.5
	91.00	1			1 4.8
	Column Total	11 52.4	8 38.1	2 9.5	21 100.0

Page 19 DEMOTIONS
7/18/93
VALUES ARE # DEMOTED TO THAT PG DURING THE FY.

YEAR by PAYGRADE

Count	PAYGRADE E-3	E-4	E-5	E-6	
YEAR	3.00	4.00	5.00	6.00	Row Total
84.00	14	13	4	1	32 22.4
85.00	9	6	4	2	21 14.7
86.00	10	3	2	2	17 11.9
87.00	20	8	4		32 22.4
88.00	4	1	5	1	11 7.7
89.00	7	2	2	1	12 8.4
90.00	5	2	2	1	10 7.0
91.00	2	5	1		8 5.6
Column Total	71 49.7	40 28.0	24 16.8	8 5.6	143 100.0

VALUES ARE # THAT SEPARATED DURING THE FY.

YEAR by PAYGRADE

YEAR	Count	PAYGRADE E-3 3.00	E-4 4.00	E-5 5.00	E-6 6.00	E-7 7.00	E-8 8.00	E-9 9.00	Row Total
	84.00	66	264	128	48	59	10	16	591 14.0
	85.00	28	246	145	48	40	15	6	528 12.5
	86.00	14	263	156	67	55	15	8	578 13.7
	87.00	12	240	117	66	56	17	12	520 12.3
	88.00	15	285	123	45	69	6	9	552 13.1
	89.00	6	206	104	51	60	9	1	437 10.4
	90.00	9	280	109	49	108	17	9	581 13.8
	91.00	8	225	80	28	71	13	3	428 10.2
	Column Total	158 3.7	2009 47.7	962 22.8	402 9.5	518 12.3	102 2.4	64 1.5	4215 100.0

Page 25 ANNUAL TIME IN SERVICE DATA
7/18/93
Values are mean TIS for beginning of FY inventories.

Summaries of TIS
By levels of PAYGRADE
BEG_YR

Variable	Value	Mean	Std Dev	Cases
For Entire Population		8.4985	5.0830	33228
PAYGRADE	3.00	2.7374	1.9190	588
BEG_YR	84.00	3.1124	1.1662	187
BEG_YR	85.00	3.7074	1.7590	59
BEG_YR	86.00	3.3858	1.7702	30
BEG_YR	87.00	3.7193	1.8371	35
BEG_YR	88.00	5.0302	3.0182	24
BEG_YR	89.00	3.5353	2.2588	21
BEG_YR	90.00	4.6119	2.1639	10
BEG_YR	91.00	3.0345	3.1427	29
BEG_YR	92.00	1.2851	.9707	193
PAYGRADE	4.00	4.2489	2.0348	10728
BEG_YR	84.00	3.9134	1.5301	1157
BEG_YR	85.00	3.9772	1.7127	1250
BEG_YR	86.00	4.0544	1.8481	1274
BEG_YR	87.00	4.2404	1.8891	1310
BEG_YR	88.00	4.5280	2.0226	1207
BEG_YR	89.00	4.2855	2.2021	1264
BEG_YR	90.00	4.5438	2.2619	1136
BEG_YR	91.00	4.4992	2.3010	1033
BEG_YR	92.00	4.2582	2.3720	1097
PAYGRADE	5.00	7.3175	2.9306	8478
BEG_YR	84.00	5.6045	2.4017	930
BEG_YR	85.00	6.0868	2.3772	936
BEG_YR	86.00	6.5761	2.4773	986
BEG_YR	87.00	7.0627	2.6303	879
BEG_YR	88.00	7.4007	2.7702	894
BEG_YR	89.00	7.7208	2.7727	954
BEG_YR	90.00	8.1829	2.8890	985
BEG_YR	91.00	8.4659	3.1220	953
BEG_YR	92.00	8.6642	3.1827	961
PAYGRADE	6.00	10.9716	3.4324	7878
BEG_YR	84.00	9.2240	3.3304	885
BEG_YR	85.00	9.4022	3.2755	928
BEG_YR	86.00	10.1095	3.2718	927
BEG_YR	87.00	10.4675	3.1870	925
BEG_YR	88.00	10.9440	3.1683	894
BEG_YR	89.00	11.6399	3.1840	856
BEG_YR	90.00	12.2056	3.1495	823
BEG_YR	91.00	12.4300	3.1635	815
BEG_YR	92.00	12.8102	3.0665	825

Values are mean TIS for beginning of FY inventories.
Criterion Variable TIS

Variable	Value	Mean	Std Dev	Cases
PAYGRADE	7.00	14.7895	3.3652	4691
BEG_YR	84.00	13.8552	3.7553	493
BEG_YR	85.00	13.7961	3.5678	512
BEG_YR	86.00	14.0496	3.3778	500
BEG_YR	87.00	14.3706	3.3352	525
BEG_YR	88.00	14.6696	3.2972	546
BEG_YR	89.00	14.9577	3.1442	541
BEG_YR	90.00	15.5060	3.0720	536
BEG_YR	91.00	15.7998	3.0088	520
BEG_YR	92.00	15.9947	2.8677	518
PAYGRADE	8.00	18.2991	3.3409	545
BEG_YR	84.00	17.9556	3.6498	67
BEG_YR	85.00	17.8901	3.5740	68
BEG_YR	86.00	18.2074	3.7279	67
BEG_YR	87.00	17.7199	2.9146	58
BEG_YR	88.00	17.6059	2.9851	54
BEG_YR	89.00	18.3477	3.2353	59
BEG_YR	90.00	18.9229	3.0380	56
BEG_YR	91.00	18.7011	3.2096	55
BEG_YR	92.00	19.4152	3.2148	61
PAYGRADE	9.00	23.0430	5.0543	320
BEG_YR	84.00	23.5447	4.2165	43
BEG_YR	85.00	22.2821	4.2860	41
BEG_YR	86.00	22.1943	4.6989	43
BEG_YR	87.00	23.0001	4.6176	41
BEG_YR	88.00	23.1554	5.3522	35
BEG_YR	89.00	23.2888	5.6464	28
BEG_YR	90.00	23.8752	5.6014	29
BEG_YR	91.00	23.1795	6.0650	29
BEG_YR	92.00	23.3328	5.9246	31

Total Cases = 33229
Missing Cases = 1 OR .0 PCT.

Page 29 PROMOTEES TIME IN SERVICE DATA
7/18/93
Values are mean TISADV for promotees to that PG.

Summaries of TISADV
By levels of PAYGRADE
YR

Variable	Value	Mean	Std Dev	Cases
For Entire Population		7.7028	4.2755	3960
PAYGRADE	4.00	2.9899	1.4351	176
YR	84	2.9319	.9926	86
YR	85	3.3114	1.7462	19
YR	86	2.9642	1.9183	12
YR	87	3.4591	1.3051	20
YR	88	3.6801	1.4819	6
YR	89	3.4538	2.6591	14
YR	91	1.8934	.7691	19
PAYGRADE	5.00	5.1598	2.1290	1869
YR	84	4.3437	1.7285	279
YR	85	4.6447	1.8402	273
YR	86	4.8729	1.9347	201
YR	87	5.2036	2.0679	239
YR	88	5.3769	1.9828	244
YR	89	5.5510	2.2075	2[illegible]
YR	90	5.8174	2.4881	2[illegible]
YR	91	5.8186	2.3334	195
PAYGRADE	6.00	8.2387	2.6965	1027
YR	84	6.2829	2.1134	182
YR	85	7.2624	2.2790	99
YR	86	7.5703	2.0443	154
YR	87	7.6992	2.1843	135
YR	88	8.9109	2.8132	88
YR	89	9.0018	2.4506	[illegible]2
YR	90	9.7352	2.4949	159
YR	91	10.3378	2.5091	128
PAYGRADE	7.00	12.2906	2.9034	692
YR	84	10.6125	2.9093	101
YR	85	10.6528	2.5446	51
YR	86	11.7490	2.7307	93
YR	87	11.8011	2.6682	96
YR	88	12.3122	2.7350	78
YR	89	13.1251	2.4571	63
YR	90	13.6904	2.5845	118
YR	91	13.7139	2.6265	92

Values are mean TISADV for promotees to that PG.
Criterion Variable TISADV

Variable	Value	Mean	Std Dev	Cases
PAYGRADE	8.00	16.6562	2.9990	146
YR	84	16.5652	3.4862	23
YR	85	15.2999	2.4351	22
YR	86	15.7260	2.4447	12
YR	87	15.6715	2.7232	19
YR	88	18.0163	3.9068	13
YR	89	17.0198	2.5317	8
YR	90	17.0038	2.6348	25
YR	91	18.0112	2.7720	24
PAYGRADE	9.00	18.7053	2.6355	50
YR	84	19.7394	2.9274	12
YR	85	17.4432	2.3952	8
YR	86	20.3244	2.9896	6
YR	87	17.0427	2.5523	6
YR	88	18.7885	2.4877	2
YR	89	19.1691	1.6010	2
YR	90	18.0628	2.4992	9
YR	91	19.2323	1.2751	5

Total Cases = 3960

Page 33 ATTRITEES TIME IN SERVICE DATA
7/18/93
Values are mean TIS for those attrited in that PG

Summaries of TISPLUS
By levels of PAYGRADE
BEG_YR

Variable	Value	Mean	Std Dev	Cases
For Entire Population		8.0405	5.6176	4215
PAYGRADE	3.00	4.7410	1.9860	158
BEG_YR	84.00	4.1395	1.0921	66
BEG_YR	85.00	5.0020	1.5366	28
BEG_YR	86.00	4.3563	1.5008	14
BEG_YR	87.00	5.2109	2.1145	12
BEG_YR	88.00	5.9330	3.2193	15
BEG_YR	89.00	4.6725	1.5444	6
BEG_YR	90.00	4.5283	1.1983	9
BEG_YR	91.00	6.8142	4.5409	8
PAYGRADE	4.00	4.8542	1.5920	2009
BEG_YR	84.00	4.4354	1.2226	264
BEG_YR	85.00	4.7581	1.3334	246
BEG_YR	86.00	4.8483	1.6248	263
BEG_YR	87.00	4.8376	1.6725	240
BEG_YR	88.00	5.2244	1.7064	285
BEG_YR	89.00	5.1411	1.6970	206
BEG_YR	90.00	4.7330	1.6811	280
BEG_YR	91.00	4.8942	1.6167	225
PAYGRADE	5.00	6.6466	2.7452	962
BEG_YR	84.00	5.2930	2.0063	128
BEG_YR	85.00	5.6232	1.8533	145
BEG_YR	86.00	6.7240	2.3519	156
BEG_YR	87.00	6.9303	2.9455	117
BEG_YR	88.00	7.0712	2.8774	123
BEG_YR	89.00	7.1895	2.8382	104
BEG_YR	90.00	7.2946	2.3885	109
BEG_YR	91.00	7.8601	4.0619	80
PAYGRADE	6.00	11.6730	4.8557	402
BEG_YR	84.00	11.0180	5.1674	48
BEG_YR	85.00	10.0615	4.0648	48
BEG_YR	86.00	10.5833	4.1784	67
BEG_YR	87.00	10.0649	4.3422	66
BEG_YR	88.00	11.3470	4.3489	45
BEG_YR	89.00	13.0584	4.6908	51
BEG_YR	90.00	13.4761	4.6466	49
BEG_YR	91.00	16.8018	5.0279	28

Page 34 ATTRITEES TIME IN SERVICE DATA
7/18/93
Values are mean TIS for those attrited in that PG
Criterion Variable TISPLUS

Variable	Value	Mean	Std Dev	Cases
PAYGRADE	7.00	16.9229	3.9578	518
BEG_YR	84.00	16.2134	4.9314	59
BEG_YR	85.00	18.3400	4.0779	40
BEG_YR	86.00	16.1176	3.9775	55
BEG_YR	87.00	16.2423	4.1428	56
BEG_YR	88.00	16.9581	3.8769	69
BEG_YR	89.00	16.9770	3.3783	60
BEG_YR	90.00	16.6871	3.5003	108
BEG_YR	91.00	18.1534	3.6826	71
PAYGRADE	8.00	19.4624	3.7759	102
BEG_YR	84.00	19.3025	5.1419	10
BEG_YR	85.00	17.4628	3.6322	15
BEG_YR	86.00	21.3183	4.9027	15
BEG_YR	87.00	19.2383	3.0858	17
BEG_YR	88.00	20.1377	.7679	6
BEG_YR	89.00	19.7334	4.3268	9
BEG_YR	90.00	20.5008	2.5493	17
BEG_YR	91.00	18.1867	3.1112	13
PAYGRADE	9.00	24.2468	3.4849	64
BEG_YR	84.00	25.9560	2.8441	16
BEG_YR	85.00	23.3533	2.6359	6
BEG_YR	86.00	22.8888	2.7083	8
BEG_YR	87.00	22.7875	3.3849	12
BEG_YR	88.00	25.2845	3.8432	9
BEG_YR	89.00	27.5198	.0000	1
BEG_YR	90.00	22.8299	3.7964	9
BEG_YR	91.00	26.4229	5.1812	3

Total Cases = 4215

Page 37 RECRUITS TIME IN SERVICE DATA
7/18/93
Values are mean TIS for those recruited in that PG

Summaries of TISMINUS
By levels of PAYGRADE
YR

Variable	Value	Mean	Std Dev	Cases
For Entire Population		2.6223	1.7617	4140
PAYGRADE	3.00	1.0851	1.1326	277
YR	84	1.6730	1.3767	17
YR	85	1.1442	.8090	9
YR	86	2.6917	1.3298	21
YR	87	1.2303	.6234	2
YR	88	1.9484	.9957	14
YR	89	2.6088	.1762	2
YR	90	1.3736	.8981	22
YR	91	.7376	.8994	190
PAYGRADE	4.00	2.5458	1.3942	3678
YR	84	2.4567	1.2623	555
YR	85	2.4543	1.2748	526
YR	86	2.6998	1.3861	497
YR	87	2.6611	1.5045	368
YR	88	2.5492	1.5318	583
YR	89	2.5378	1.4520	272
YR	90	2.6212	1.3548	415
YR	91	2.4320	1.3949	462
PAYGRADE	5.00	5.6334	2.4088	159
YR	84	5.1056	2.0409	39
YR	85	5.4338	2.4690	23
YR	86	4.3989	3.6627	3
YR	87	5.8599	2.2940	31
YR	88	6.3788	2.5111	23
YR	89	6.1512	2.2564	14
YR	90	5.4603	1.5217	2
YR	91	5.5422	2.9316	24
PAYGRADE	6.00	10.4196	2.8957	18
YR	84	9.3432	2.7334	9
YR	85	7.7094	.9893	2
YR	86	13.8641	1.2526	2
YR	88	10.3063	.0000	1
YR	90	11.8559	.0000	1
YR	91	12.7183	2.5928	3
PAYGRADE	7.00	13.6809	4.1660	7
YR	84	11.1131	5.0425	3
YR	85	15.8477	.0000	1
YR	86	13.5890	.0000	1
YR	89	19.0400	.0000	1
YR	91	13.9504	.0000	1
PAYGRADE	8.00	13.2194	.0000	1
YR	84	13.2194	.0000	1

Page 41 DEMOTEES TIME IN SERVICE DATA
7/18/93
Values are mean TIS for those demoted to that PG

Summaries of TISMINUS
By levels of PAYGRADE
YR

Variable	Value	Mean	Std Dev	Cases
For Entire Population		6.9405	3.9950	143
PAYGRADE	3.00	4.1943	1.7086	71
YR	84	4.3736	1.4927	14
YR	85	4.1124	1.6666	9
YR	86	4.0654	2.3636	10
YR	87	4.3671	1.7752	20
YR	88	3.9579	.7983	4
YR	89	4.3339	2.4200	7
YR	90	3.5296	.6146	5
YR	91	3.8723	.6234	2
PAYGRADE	4.00	7.9472	2.3357	40
YR	84	6.8250	1.1883	13
YR	85	8.5874	2.6367	6
YR	86	7.6424	2.4790	3
YR	87	9.3806	2.2192	8
YR	88	4.0722	.0000	1
YR	89	6.3419	.2207	2
YR	90	8.5240	4.8786	2
YR	91	9.1723	2.5768	5
PAYGRADE	5.00	10.8225	3.8417	24
YR	84	9.1105	2.8922	4
YR	85	8.5712	3.5454	4
YR	86	11.6478	4.3985	2
YR	87	13.7998	6.1958	4
YR	88	9.4044	2.3938	5
YR	89	12.4336	2.9852	2
YR	90	14.3583	.6350	2
YR	91	9.9120	.0000	1
PAYGRADE	6.00	14.6328	3.7549	8
YR	84	16.5075	.0000	1
YR	85	15.8833	6.2028	2
YR	86	11.2741	4.5785	2
YR	88	17.5890	.0000	1
YR	89	15.0756	.0000	1
YR	90	13.5753	.0000	1

Total Cases = 143

APPENDIX B
SPSS PROGRAM FOR DATA ANALYSIS

```
SET MORE=OFF.
GET FILE='CENSUS.SYS'.
SELECT IF (((MTYPE EQ 'J') OR (MTYPE EQ 'K')) AND
  (RATE EQ 200)).
SAVE OUTFILE='TEMP.SYS'
  /KEEP= RATE PAYGRADE YR MTYPE SSN ACDUDY ACDUDM
       ACDUDD YOR MOR.
GET FILE='TEMP.SYS'.
SORT CASES BY SSN(A) YR(A).
SAVE OUTFILE='DATA.SYS'.

* ADD IN MISSING YEARS.
GET FILE='DATA.SYS'.
IF ((SSN EQ LAG(SSN)) AND (YR - LAG(YR) GT 1) AND
  (YR - LAG(YR) LE 4) AND (MTYPE EQ 'J')
  AND (ACDUDY EQ LAG(ACDUDY)) AND (ACDUDM EQ LAG(ACDUDM)))
  COR=1.
SAVE OUTFILE='TEMP.SYS'.
GET FILE='TEMP.SYS'.
SELECT IF (COR EQ 1).
COMPUTE YR=YR - 1.
SAVE OUTFILE='CORRECT.SYS'.
  /DROP=COR.

JOIN ADD FILE='DATA.SYS'
  /FILE='CORRECT.SYS'.
SORT CASES BY SSN(A) YR(A).
SAVE OUTFILE='DATA1.SYS'.

GET FILE='DATA1.SYS'.
IF ((SSN EQ LAG(SSN)) AND (YR - LAG(YR) GT 1) AND
  (YR - LAG(YR) LE 3) AND (MTYPE EQ 'J')
  AND (ACDUDY EQ LAG(ACDUDY)) AND (ACDUDM EQ LAG(ACDUDM)))
  COR=1.
SAVE OUTFILE='TEMP.SYS'.
GET FILE='TEMP.SYS'.
SELECT IF (COR EQ 1).
COMPUTE YR=YR - 1.
```

```
SAVE OUTFILE='CORRECT.SYS'
  /DROP=COR.

JOIN ADD FILE='DATA1.SYS'
  /FILE='CORRECT.SYS'.
SORT CASES BY SSN(A) YR(A).
SAVE OUTFILE='DATA.SYS'.

* CORRECT PAYGRADE AND YOR, MOR ON NEW RECORDS.
GET FILE='DATA.SYS'.
IF ((SSN EQ LAG(SSN)) AND (YR LT(YOR)) AND (ACDUDY EQ LAG(ACDUDY))
   AND (ACDUDM EQ LAG(ACDUDM))
   AND (PAYGRADE - LAG(PAYGRADE) EQ 1))  COR=1.
SAVE OUTFILE='TEMP.SYS'.
GET FILE='TEMP.SYS'.
IF (COR EQ 1) PAYGRADE = PAYGRADE - 1.
IF (COR EQ 1) YOR = LAG(YOR).
IF (COR EQ 1) MOR = LAG(MOR).
SAVE OUTFILE='DATA1.SYS'
   /DROP=COR.

* MAKE ALL YOR MOR THE SAME FOR EACH PAYGRADE.
GET FILE='DATA1.SYS'.
IF ((SSN EQ LAG(SSN)) AND (PAYGRADE EQ LAG(PAYGRADE)) AND
   (ACDUDY EQ LAG(ACDUDY)) AND (ACDUDM EQ LAG(ACDUDM)) AND
   (YOR NE LAG(YOR))) YOR=LAG(YOR).
IF ((SSN EQ LAG(SSN)) AND (PAYGRADE EQ LAG(PAYGRADE)) AND
   (ACDUDY EQ LAG(ACDUDY)) AND (ACDUDM EQ LAG(ACDUDM)) AND
   (MOR NE LAG(MOR))) MOR=LAG(MOR).
SAVE OUTFILE='DATA.SYS'.

* CONDUCT ANALYSIS.
SET LISTING='ANALYSIS.LIS'
   /LENGTH=59  /WIDTH=WIDE.
GET FILE='DATA.SYS'.
TITLE WHAT ARE THE FREQS.
FREQUENCIES VARIABLES= YR RATE PAYGRADE MTYPE YOR MOR
  ACDUDY ACDUDM ACDUDD
  /MISSING=INCLUDE.

TITLE ARE THERE ANY MORE DISJOINT YEARS.
IF ((SSN EQ LAG(SSN)) AND (YR - LAG(YR) GT 1) AND
  (MTYPE EQ 'J') AND (ACDUDY EQ LAG(ACDUDY))) COR=1.
SAVE OUTFILE='TEMP.SYS'.
```

```
GET FILE='TEMP.SYS'.
SORT CASES BY SSN(A) COR(D).
IF ((SSN EQ LAG(SSN)) AND (LAG(COR) EQ 1)) COR=1.
SAVE OUTFILE='TEMP1.SYS'.
GET FILE='TEMP1.SYS'.
SORT CASES BY SSN(A) YR(A).
SAVE OUTFILE='TEMP.SYS'.
GET FILE='TEMP.SYS'.
SELECT IF (COR EQ 1).
LIST VARIABLES= SSN YR PAYGRADE MTYPE YOR MOR ACDUDY ACDUDD.

TITLE 'IS THERE DATES OF RANK LATER THAN YEAR'.
GET FILE='DATA.SYS'.
IF (YR LT YOR) COR=1.
SAVE OUTFILE='TEMP.SYS'.
GET FILE='TEMP.SYS'.
SORT BY SSN(A) COR(D).
IF ((SSN EQ LAG(SSN)) AND (LAG(COR) EQ 1)) COR=1.
SAVE OUTFILE='TEMP1.SYS'.
GET FILE='TEMP1.SYS'.
SORT CASES BY SSN(A) YR(A).
SAVE OUTFILE='TEMP.SYS'.
GET FILE='TEMP.SYS'.
SELECT IF (COR EQ 1).
LIST VARIABLES= SSN YR PAYGRADE MTYPE YOR MOR ACDUDY ACDUDM.
```

```
SET MORE=OFF.
******COMPUTE ADDITIONAL VARIABLES******.
GET FILE='THESIS.SYS'.
**** CHANGE END OF YR TO BEGINNING OF YR.
COMPUTE BEG_YR = YR + 1.
COMPUTE PG = PAYGRADE.
COMPUTE FIRSTCSE = LAG(PG).
**** COMBINE E2 AND E3 INTO ONE PAYGRADE .
RECODE PAYGRADE (2=3).
**** RECRUIT.
IF ((YR NE 83) AND ((SYSMIS(FIRSTCSE)) OR
   (SSN NE LAG(SSN)) OR
   ((SSN EQ LAG(SSN)) AND (YR - LAG(YR) GT 1))))
   RECRUIT = 1.
**** PROMOTE .
IF ((SSN EQ LAG(SSN)) AND (PAYGRADE - LAG(PAYGRADE) EQ 1)
   AND (YR - LAG(YR) EQ 1))
  PROMOTE1 = 1.
**** TWO PROMOTIONS.
IF ((SSN EQ LAG(SSN)) AND (PAYGRADE - LAG(PAYGRADE) EQ 2)
   AND (YR - LAG(YR) EQ 1))
  PROMOTE2 = 1.
**** DEMOTIONS.
IF ((SSN EQ LAG(SSN)) AND (LAG(PAYGRADE) - PAYGRADE EQ 1)
   AND (YR - LAG(YR) EQ 1))
   DEMOTE = 1.
SAVE OUTFILE='TEMP.SYS'
   /DROP = FIRSTCSE.

GET FILE='TEMP.SYS'.
SORT CASES BY SSN(A) YR(D).
COMPUTE FIRSTCSE = LAG(PG).
**** YEAR BEFORE PROMOTIONS.
IF (LAG(PROMOTE1) EQ 1) BEF_PROM = 1.
**** SEPARATIONS.
IF ((YR NE 91) AND ((SYSMIS(FIRSTCSE)) OR
   (SSN NE LAG(SSN)) OR
   ((SSN EQ LAG(SSN)) AND (LAG(YR) - YR GT 1))))
   SEPARATE = 1.

SAVE OUTFILE='TEMP2.SYS'
   /DROP = FIRSTCSE.

GET FILE='TEMP2.SYS'.
```

```
SORT CASES BY SSN(A) YR(A).
COMPUTE
TISADV=(YRMODA(YOR,MOR,1)-YRMODA(ACDUDY,ACDUDM,ACDUDD))/365.25.
COMPUTE TIS=(YRMODA(YR,9,30)-YRMODA(ACDUDY,ACDUDM,ACDUDD))/365.25.
COMPUTE
TISPLUS=(YRMODA(YR,9,30)-YRMODA(ACDUDY,ACDUDM,ACDUDD))/365.25+0.5.
COMPUTE
TISMINUS=(YRMODA(YR,9,30)-YRMODA(ACDUDY,ACDUDM,ACDUDD))/365.25-0.5.
SAVE OUTFILE='THESIS.SYS'.

SET LISTING = 'THESIS.LIS'
  /LENGTH=59 /WIDTH = WIDE.

**** CONSTRUCT ANNUAL TABLES.
GET FILE='THESIS.SYS'.
TITLE 'ANNUAL DATA'.
SUBTITLE 'VALUES ARE # IN PAYGRADE AT BEGINNING OF YEAR'.
COMPUTE YEAR = BEG_YR.
CROSSTABS YEAR BY PAYGRADE.

GET FILE='THESIS.SYS'.
IF (RECRUIT EQ 1) YEAR = YR.
TITLE 'RECRUITMENT'.
SUBTITLE 'VALUES ARE # RECRUITED DURING THAT FY.'.
CROSSTABS YEAR BY PAYGRADE.

GET FILE='THESIS.SYS'.
IF (PROMOTE1 EQ 1) YEAR = YR.
TITLE 'SINGLE ADVANCEMENTS IN ONE YEAR'.
SUBTITLE 'VALUES ARE # PROMOTED TO THAT PG DURING THE FY.'.
TITLE 'THAT PAYGRADE DURING THE YEAR'.
CROSSTABS YEAR BY PAYGRADE.

GET FILE='THESIS.SYS'.
IF (PROMOTE2 EQ 1) YEAR = YR.
TITLE 'TWO ADVANCEMENTS IN ONE YEAR'.
SUBTITLE 'VALUES ARE # PROMOTED TO THAT PG DURING THE FY.'.
CROSSTABS YEAR BY PAYGRADE.

GET FILE='THESIS.SYS'.
IF (DEMOTE EQ 1) YEAR = YR.
TITLE 'DEMOTIONS'.
SUBTITLE 'VALUES ARE # DEMOTED TO THAT PG DURING THE FY.'.
CROSSTABS YEAR BY PAYGRADE.
```

```
GET FILE='THESIS.SYS'.
IF (SEPARATE EQ 1) YEAR = BEG_YR.
TITLE 'SEPARATIONS'.
SUBTITLE 'VALUES ARE # THAT SEPARATED DURING THE FY.'.
CROSSTABS YEAR BY PAYGRADE.

****CONSTRUCT ANNUAL TIS TABLES****.
GET FILE='THESIS.SYS'.
TITLE 'ANNUAL TIME IN SERVICE DATA'.
SUBTITLE 'Values are mean TIS for beginning of FY inventories.'.
MEANS TABLE = TIS BY PAYGRADE BY BEG_YR
  /OPTIONS = 3.

GET FILE='THESIS.SYS'.
SELECT IF (PROMOTE1 EQ 1).
TITLE "PROMOTEES TIME IN SERVICE DATA".
SUBTITLE "Values are mean TISADV for promotees to that PG.".
MEANS TABLE = TISADV BY PAYGRADE BY YR
  /OPTIONS = 3.

GET FILE='THESIS.SYS'.
SELECT IF (SEPARATE EQ 1).
TITLE "ATTRITEES TIME IN SERVICE DATA".
SUBTITLE "Values are mean TIS for those attrited in that PG".
MEANS TABLE = TISPLUS BY PAYGRADE BY BEG_YR
  /OPTIONS = 3.

GET FILE='THESIS.SYS'.
SELECT IF (RECRUIT EQ 1).
TITLE "RECRUITS TIME IN SERVICE DATA".
SUBTITLE "Values are mean TIS for those recruited in that PG".
MEANS TABLE = TISMINUS BY PAYGRADE BY YR
  /OPTIONS = 3.

GET FILE='THESIS.SYS'.
SELECT IF (DEMOTE EQ 1).
TITLE "DEMOTEES TIME IN SERVICE DATA".
SUBTITLE "Values are mean TIS for those demoted to that PG".
MEANS TABLE = TISMINUS BY PAYGRADE BY YR
  /OPTIONS = 3.

FINISH.
```

APPENDIX C
MK 1989 VALIDATION MODEL

	A	B	C	D	E	F	G	H	I	J
1	**COAST GUARD RATING FORECAST MODEL**									
2	By: LCDR Mark J. FIEBRANDT									
3	24 Sept. 1993									
4										
5	This model forecasts manpower requirements for a specific CG rating over a five year period of									
6	time. The model will provide for each paygrade annual stocks and flows along with mean Time									
7	in Service for each flow group.									
8	The model requires input of certain historical data and model starting point values in order									
9	to estimate certain model parameters and forecast future system movements. The following									
10	pages of this spreadsheet will be for input of data. Cells which require to be filled are hi-lighted by									
11	a gray box. Note that the historical data consists of eight consecutive years of information. It									
12	is not completely necessary to have the full eight years but should have at a minimum of four									
13	years. In any case the most recent year of data gets filled in the bottom row of historical data									
14	matrices and proceeds upwards to less recent years.									
15	Lines 20 through 84 (Data Entry Section) contain questions which are for a specific model,									
16	whereas lines 85 through 235 (Historical Data Input Section) are generic for model year and rating.									
17	This means once the Historical Data Input Section is filled, different model runs may be made by									
18	changing values in the Data Entry Section. It is recommended that the Historical Data Input									
19	Section be filled in first, then the Data Entry Section completed to run a specific model.									
20										
21										
22										

	A	B	C	D	E	F	G	H	I	J
23	**DATA ENTRY SECTION**									
24										
25	What rating do you wish to forecast for?					**MK**				
26										
27	What fiscal year does the model start its forecast?						**1989**			
28										
29	What are the beginning of year personnel inventories e(t-1), for the							MK	rating?	
30	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	Total	
31	Inventory	**21**	**1264**	**954**	**856**	**541**	**59**	**28**	372	
32										
33	What are the beginning of year number of billets, n(t-1), for the							MK	rating?	
34	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	Total	
35	Inventory	**73**	**1042**	**983**	**862**	**546**	**59**	**29**	3594	
36										
37	What are the average Time in Service (TIS) values for beginning of year personnel inventories?									
38	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9		
39	Inventory	**3.53**	**4.28**	**7.72**	**11.63**	**14.95**	**18.34**	**23.28**		
40										
41	What are the end of first year forecasted number of billets, n(t), for the							MK	rating?	
42	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	Total	
43	Inventory	**73**	**1098**	**990**	**827**	**537**	**54**	**29**	3608	
44										
45	What additional changes in number of billets n(t) may occur in the first year?									
46	Note: Positive values will increase the # of billets while negative values decrease the # of billets.									
47	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	Total	
48	Deltas	**0**	**0**	**0**	**0**	**0**	**0**	**0**	0	
49										
50	What is the forecasted billets growth/accession (in percentages) for years two through five?									
51	Note: A 5% annual growth rate would be represented by 1.05 and is compounded each year.									
52	ie. A 5% accession (0.95) would be 95% of previous years billets. The rate for								1989	was
53	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9		
54	1989	1	1.05374	1.00712	0.9594	0.98352	0.91525	1		
55	Forecasted rates are:									
56	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9		
57	1990	**1**	**0.998**	**0.984**	**0.993**	**0.968**	**1.093**	**1**		
58	1991	**0.918**	**1.027**	**1.018**	**1.001**	**1.002**	**1**	**1.069**		
59	1992	**0.925**	**0.988**	**0.998**	**0.99**	**0.975**	**0.966**	**1.032**		
60	1993	**0.984**	**1.027**	**1.013**	**1.002**	**1**	**1.07**	**1.031**		
61										
62	What is the forecasted attrition rates for years one through five?									
63	Note: The rates inputted are the exact rates used by the model and represent all attrition									

	A	B	C	D	E	F	G	H	I	J
64	from the rating. The previous year's attrition rates are:									
65	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9		
66	Rate:	0.34286	0.18321	0.13311	0.07135	0.10667	0.2931	0.29268		
67	Forecasted rates are:									
68	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9		
69	1989	**0.2857**	**0.163**	**0.109**	**0.0596**	**0.1109**	**0.1525**	**0.0357**		
70	1990	**0.9**	**0.2465**	**0.1107**	**0.0595**	**0.2015**	**0.3036**	**0.3103**		
71	1991	**0.2759**	**0.2178**	**0.084**	**0.0344**	**0.1365**	**0.2364**	**0.1034**		
72	1992	**0.27586**	**0.1689**	**0.0582**	**0.0388**	**0.0731**	**0.2203**	**0.0968**		
73	1993	**0.27586**	**0.1689**	**0.0582**	**0.0388**	**0.0731**	**0.2203**	**0.0968**		
74										
75	What is the maximum allowed change in promotion rates from year to year (In percentages)?									
76	The current promotion rates are:									
77	Paygrade		E-4	E-5	E-6	E-7	E-8	E-9		
78	Rate		0.57143	0.18244	0.15358	0.10378	0.03619	0.10345		
79	Paygrade		E-4	E-5	E-6	E-7	E-8	E-9		
80	% Change Up		**0.05**	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**		
81	% Change Down		**0.05**	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**		
82										
83	What is the minimum r squared allowed for using linear regression as a TIS predictor?									
84	Values 0 to 1.0. Recommend 0.8.				**0.8**					
85										
86										
87	What is the minimum and maximum annual number of "A" school graduates allowed?									
88	Min #	**100**								
89	Max #	**600**								
90										
91	**HISTORICAL DATA INPUT SECTION**									
92										
93	What years of historical data is available? See ANNUAL DATA chart for years.									
94	First Year:	**1984**								
95	Last Year:	**1988**								
96										
97	What weights do you wish to place on the annual historical data?									
98	Year	1980	1981	1982	1983	1984	1985	1986	1987	
99	Weight	**0**	**0**	**0**	**0**	**1**	**2**	**3**	**4**	
100										
101	Input the ANNUAL DATA chart by paygrade.									
102		Paygrade								
103	Year	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	Totals	
104	1980	**0**	**0**	**0**	**0**	**0**	**0**	**0**	0	
105	1981	**0**	**0**	**0**	**0**	**0**	**0**	**0**	0	

	A	B	C	D	E	F	G	H	I	J
106	1982	0	0	0	0	0	0	0	0	
107	1983	0	0	0	0	0	0	0	0	
108	1984	187	1157	930	885	493	67	43	3762	
109	1985	59	1250	936	928	512	66	41	3794	
110	1986	30	1274	986	927	500	67	43	3827	
111	1987	35	1310	879	925	525	58	41	3773	
112	1988	24	1207	894	894	546	54	35	3654	
113	Totals:	335	6198	4625	4559	2576	314	203	18810	
114										
115										
116	Input the SINGLE PROMOTION DATA chart by paygrade.									
117		Paygrade								
118	Year	E-4	E-5	E-6	E-7	E-8	E-9	Totals		
119	1980	0	0	0	0	0	0	0		
120	1981	0	0	0	0	0	0	0		
121	1982	0	0	0	0	0	0	0		
122	1983	0	0	0	0	0	0	0		
123	1984	86	279	182	101	23	12	683		
124	1985	19	273	99	51	22	8	472		
125	1986	12	201	154	93	12	6	478		
126	1987	20	239	135	96	19	6	515		
127	Totals:	137	992	570	341	76	32	2148		
128										
129										
130	Input the DEMOTION DATA chart by paygrade.									
131		Paygrade								
132	Year	E-2/3	E-4	E-5	E-6	E-7	E-8	Totals		
133	1980	0	0	0	0	0	0	0		
134	1981	0	0	0	0	0	0	0		
135	1982	0	0	0	0	0	0	0		
136	1983	0	0	0	0	0	0	0		
137	1984	14	13	4	1	0	0	32		
138	1985	9	6	4	2	0	0	21		
139	1986	10	3	2	2	0	0	17		
140	1987	20	8	4	0	0	0	32		
141	Totals:	53	30	14	5	0	0	102		
142										
143										
144	Input the SEPARATIONS DATA chart by paygrade.									
145		Paygrade								
146	Year	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	Totals	
147	1980	0	0	0	0	0	0	0	0	

	A	B	C	D	E	F	G	H	I	J
148	1981	0	0	0	0	0	0	0	0	
149	1982	0	0	0	0	0	0	0	0	
150	1983	0	0	0	0	0	0	0	0	
151	1984	66	264	128	48	59	10	16	591	
152	1985	26	246	145	48	40	15	6	528	
153	1986	14	263	156	67	55	15	8	578	
154	1987	12	240	117	66	56	17	12	520	
155	Totals:	120	1013	546	229	210	57	42	2217	
156										
157										
158	Input the RECRUITMENT DATA chart by paygrade.									
159		Paygrade								
160	Year	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	Totals	
161	1980	0	0	0	0	0	0	0	0	
162	1981	0	0	0	0	0	0	0	0	
163	1982	0	0	0	0	0	0	0	0	
164	1983	0	0	0	0	0	0	0	0	
165	1984	17	555	39	9	3	1	0	624	
166	1985	9	526	23	2	1	0	0	561	
167	1986	21	497	3	2	1	0	0	524	
168	1987	2	368	31	0	0	0	0	401	
169	Totals:	49	1946	96	13	5	1	0	2110	
170										
171	**HISTORICAL TIME IN SERVICE DATA INPUT SECTION**									
172										
173	Input the ANNUAL MEAN TIME IN SERVICE (TIS) DATA chart by paygrade.									
174		Paygrade								
175	Year	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9		
176	1980	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
177	1981	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
178	1982	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
179	1983	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
180	1984	3.11	3.91	5.60	9.22	13.86	17.96	23.54		
181	1985	3.71	3.98	6.09	9.40	13.80	17.89	22.28		
182	1986	3.39	4.05	6.58	10.11	14.05	18.21	22.19		
183	1987	3.72	4.24	7.06	10.47	14.37	17.72	23.00		
184	1988	5.03	4.53	7.40	10.94	14.67	17.61	23.16		
185										
186										
187	Input the PROMOTED MEAN TIME IN SERVICE (TIS) DATA chart by paygrade.									
188	Cell values are mean TISADV for those promoted to that paygrade during that year.									
189		Paygrade								

	A	B	C	D	E	F	G	H	I	J
190	Year	E-4	E-5	E-6	E-7	E-8	E-9			
191	1980	0.00	0.00	0.00	0.00	0.00	0.00			
192	1981	0.00	0.00	0.00	0.00	0.00	0.00			
193	1982	0.00	0.00	0.00	0.00	0.00	0.00			
194	1983	0.00	0.00	0.00	0.00	0.00	0.00			
195	1984	2.93	4.34	6.28	10.61	16.57	19.74			
196	1985	3.31	4.64	7.26	10.65	15.30	17.44			
197	1986	2.96	4.87	7.57	11.75	15.73	20.32			
198	1987	3.46	5.20	7.70	11.80	15.67	17.04			
199										
200										
201	Input the ATTRITEES MEAN TIME IN SERVICE (TIS) DATA chart by paygrade.									
202	Cell values are mean TIS for those attrited from that paygrade during that year.									
203		Paygrade								
204	Year	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9		
205	1980	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
206	1981	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
207	1982	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
208	1983	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
209	1984	4.14	4.44	5.29	11.02	16.21	19.30	25.96		
210	1985	5.00	4.76	5.62	10.06	18.34	17.46	23.35		
211	1986	4.36	4.85	6.72	10.58	16.12	21.32	22.89		
212	1987	5.21	4.84	6.93	10.06	16.24	19.24	22.79		
213										
214										
215	Input the RECRUITS MEAN TIME IN SERVICE (TIS) DATA chart by paygrade.									
216	Cell values are mean TIS for those recruited to that paygrade during that year.									
217		Paygrade								
218	Year	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9		
219	1980	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
220	1981	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
221	1982	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
222	1983	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
223	1984	1.67	2.46	5.11	9.34	11.11	13.22	0.00		
224	1985	1.14	2.45	5.43	7.71	15.85	0.00	0.00		
225	1986	2.69	2.70	4.40	13.86	13.59	0.00	0.00		
226	1987	1.23	2.66	5.86	10.31	19.04	0.00	0.00		
227										
228										
229	Input the DEMOTEES MEAN TIME IN SERVICE (TIS) DATA chart by paygrade.									
230	Cell values are mean TIS for those demoted to that paygrade during that year.									
231		Paygrade								

	A	B	C	D	E	F	G	H	I	J
232	Year	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9		
233	1980	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
234	1981	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
235	1982	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
236	1983	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
237	1984	4.37	6.83	9.11	16.51	0.00	0.00	0.00		
238	1985	4.11	8.59	8.57	15.88	0.00	0.00	0.00		
239	1986	4.07	7.64	11.65	11.27	0.00	0.00	0.00		
240	1987	4.37	9.38	13.80	0.00	0.00	0.00	0.00		
241										
242										
243										

	K	L	M	N	O	P	Q	R	S
92	TRANSISTION MATRIX S								
93									
94		E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	REC
95	E-2/3	0	0.221757	0	0	0	0	0	0.778243
96	E-4	0.064837	0	0.014198	0	0	0	0	0.920965
97	E-5	0	0.900181	0	0.012704	0	0	0	0.087114
98	E-6	0	0	0.969388	0	0.008503	0	0	0.022109
99	E-7	0	0	0	0.985549	0	0	0	0.014451
100	E 8	0	0	0	0	0.987013	0	0	0.012987
101	E-9	0	0	0	0	0	1	0	0
102									
103									
104	IDENTITY MATRIX I								
105									
106		E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
107	E-2/3	1	0	0	0	0	0	0	
108	E-4	0	1	0	0	0	0	0	
109	E-5	0	0	1	0	0	0	0	
110	E-6	0	0	0	1	0	0	0	
111	E-7	0	0	0	0	1	0	0	
112	E-8	0	0	0	0	0	1	0	
113	E-9	0	0	0	0	0	0	1	
114									
115									
116	IDENTITY MATRIX - TRANSISTION MATRIX (I - S)								
117									
118		E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
119	E-2/3	1	-0.22176	0	0	0	0	0	
120	E-4	-0.06484	1	-0.0142	0	0	0	0	
121	E-5	0	-0.90018	1	-0.0127	0	0	0	
122	E-6	0	0	-0.96939	1	-0.0085	0	0	
123	E-7	0	0	0	-0.98555	1	0	0	
124	E-8	0	0	0	0	-0.98701	1	0	
125	E-9	0	0	0	0	0	-1	1	
126									
127									

	K	L	M	N	O	P	Q	R	S
128	FUNDAMENTAL MATRIX								
129									
130		E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
131	E-2/3	1.014782	0.227986	0.003278	4.2E-05	3.57E-07	0	0	
132	E-4	0.066658	1.028087	0.01478	0.000189	1.61E-06	0	0	
133	E-5	0.060759	0.937103	1.026048	0.013145	0.000112	0	0	
134	E-6	0.059396	0.916093	1.003044	1.021302	0.008685	0	0	
135	E-7	0.058538	0.902855	0.988549	1.006543	1.008559	0	0	
136	E-8	0.057778	0.89113	0.975711	0.993471	0.995461	1	0	
137	E-9	0.057778	0.89113	0.975711	0.993471	0.995461	1	1	
138									
139									
140									

	A	B	C	D	E	F	G	H	I	J
244	**RESULTS FOR FISCAL YEAR**					**1989**				
245										
246										
247	**Beginning of Year Values:**									
248	Paygrade:		E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	Total
249	Inventories: e(t-1)		21	1264	954	856	541	59	28	3723
250	Billets: n(t-1)		73	1042	983	862	546	59	29	3594
251	Inventory TIS:		3.53	4.28	7.72	11.63	14.95	18.34	23.28	N/A
252	Attrition Rate: w		0.2857	0.163	0.109	0.0596	0.1109	0.1525	0.0357	N/A
253										
254										
255	**Flows for fiscal year**			**1989**						
256	Values are number moved to that paygrade during the fiscal year.									
257	Paygrade:		E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	Total
258	Promotions:		0	13	219	99	63	7	3	404
259	Recruitment:		55	258	21	2	1	0	0	337
260	Attrition:		6	206	104	51	60	9	1	437
261	Demotions:		16	4	3	1	0	0	0	24
262										
263										
264	**Time In Service Mean Values:**									
265	Values are mean TIS for those moved to that paygrade during the year.									
266	See Flows box above for number moved.									
267	Paygrade:		E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
268	TISADV: Promotees		0	3.2068	5.34983	8.50267	13.203	16.6387	18.8566	
269	TIS: Attritees		4.75998	4.98927	7.85496	11.9603	17.499	19.9464	24.0196	
270	TIS: Recruited		2.20622	2.7135	6.55657	12.0953	14.0107	13.5178	23.28	
271	TIS: Demoted		4.45596	9.99233	13.5003	14.2233	18.34	23.28	0	
272										
273										
274	**End of Year Values:**									
275	Paygrade:		E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	Total
276	Inventory: e(t)		73	1098	990	841	537	54	30	3623
277	Billets: n(t)		73	1098	990	827	537	54	29	3608
278	Inventory TIS:		2.71944	4.32055	7.84145	12.0002	15.3187	18.6934	23.713	N/A
279										
280	diff		0	0	0	-14	0	0	-1	
281										

	K	L	M	N	O	P	Q	R	S
244	**FIRST YEAR CALCULATIONS**								
245									
246									
247	Total Vacancies (v(t-1) + e(t-1) w + m):								
248	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
249	TV	52.9997	45.032	153.986	22.0176	55.9969	4.9975	1.9996	
250									
251	Vacancy Vector v(t): Equals number of vacancies that appear in each paygrade.								
252	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
253	Vacancy	71.13085	279.6433	243.1037	87.83627	63.65004	6.9971	1.9996	
254									
255	Weighted Average TIS: Weighted by year and number in category.								
256	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
257	Weight	3.448441	4.103028	6.563933	10.02581	14.11188	17.93519	22.66659	
258									
259	Weighted Average Promotion TISADV: Weighted by year and number in category.								
260	Paygrade	E-4	E-5	E-6	E-7	E-8	E-9		
261	Weight	3.172566	4.891317	7.406629	11.51044	15.70595	18.4404		
262									
263	Multipliers for those promoted: TISADV C values								
264	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
265	C value	N/A	0.92	1.192124	1.128383	1.148081	1.11296	1.028168	
266									
267	Weighted Average Attrition TIS: Weighted by year and number in category.								
268	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
269	Weight	4.652862	4.782968	6.424257	10.31058	16.51794	19.50612	23.38667	
270									
271	Multipliers for those attrited: TIS_ATT C values								
272	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
273	C value	1.349265	1.165717	0.978721	1.028404	1.170499	1.087589	1.031768	
274									
275	Weighted Average Recruit TIS: Weighted by year and number in category.								
276	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
277	Weight	2.155246	2.601298	5.574729	10.42689	13.22521	13.2194	#DIV/0!	
278									
279	Multipliers for those recruited: TIS_REC C values								
280	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
281	C value	0.624991	0.633995	0.849297	1.040006	0.937169	0.737065	1	
282									
283	Weighted Average Demoted TIS: Weighted by year and number in category.								
284	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	

	K	L	M	N	O	P	Q	R	S
285	Weight	4.271715	8.495979	11.63809	13.42594	#DIV/0!	#DIV/0!	N/A	
286									
287	Multipliers for those demoted: TIS_DEM C values								
288	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
289	C value	1.041113	1.294343	1.160814	0.951393	1	1	N/A	
290									
291									
292									

	T	U	V	W	X	Y	Z	AA	AB
244	**MORE CALCULATIONS**								
245									
246									
247	Recruitment Vector (Rj): From the vacancy model.								
248	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
249	Recruits	55	258	21	2	1	0	0	
250	Min Rec	18	82						
251	Max Rec	105	495						
252	R > Max	55	258						
253	Final Rec	55	258						
254									
255	Allowed Promotion Rates:								
256	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
257	LAST rate	0	0.571429	0.182443	0.153584	0.103784	0.03619	0.103448	
258	Promotion	0	18	219	85	63	7	2	
259	Max #	0	13	294	194	132	47	9	
260	Min #	0	11	167	99	46	0	3	
261	P > Max	0	13	219	85	63	7	2	
262	Final P	0	13	219	99	63	7	3	
263									
264	Min # for Regression		20						
265	Promotion TISADV Regression: even weights.								
266	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
267	Slope	N/A	0.823268	2.497764	0.935978	1.092934	-0.30458	7.166453	
268	Intercept	N/A	0.300668	-5.3406	1.276921	0.492223	20.08525	-109.952	
269	Rsquared	N/A	0.846397	0.948142	0.842668	0.942416	0.021775	0.784408	
270									
271	Attrition TIS Regression: even weights.								
272	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
273	Slope	1.697659	0.981362	1.233135	-0.37655	-2.31002	5.256065	1.781628	
274	Intercept	-1.23276	0.748915	-1.66485	14.12244	49.10986	-74.9804	-16.7951	
275	Rsquared	0.931815	0.514065	0.927498	0.2291	0.30904	0.454833	0.579509	
276									
277	Recruited TIS Regression: even weights.								
278	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
279	Slope	-1.27368	0.69439	0.250882	2.60716	9.07425	1.331233	0	
280	Intercept	6.118772	-0.24177	3.611115	-15.2465	-112.304	-20.5818	0	
281	Rsquared	0.271277	0.565022	0.065626	0	0	0	0	
282									
283	Demoted TIS Regression: even weights.								
284	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	

	T	U	V	W	X	Y	Z	AA	AB
285	Slope	0.237956	1.376973	3.999153	-29.0956	0	0	0	
286	Intercept	3.266771	-0.60932	-28.4126	418.7741	0	0	0	
287	Rsquared	0.042413	0.607528	0	0	0	0	0	
288									
289									
290									
291									
292									

	AC	AD	AE	AF	AG	AH	AI	AJ	AK
244	**Third Calculation of Vacancy Model (Year 1)**								
245									
246									
247	Total Vacancies (v(t-1) + e(t-1) w + m):								
248	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
249	TV	52.9997	45.032	153.986	22.0176	55.9969	4.9975	1.9996	
250									
251	Vacancy Vector v(t): Equals number of vacancies that appear in each paygrade.								
252	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
253	Vacancy	71.13085	279.6433	243.1037	87.83627	63.65004	6.9971	1.9996	
254									
255	Recruitment Vector (Rj): From the vacancy model.								
256	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
257	Recruits	55	258	21	2	1	0	0	
258	Min Rec	18	82						
259	Max Rec	105	495						
260	R > Max	55	258						
261	Final Rec	55	258						
262									
263	Recruitment Vector (Rj): From vacancy model with recruitment constraints.								
264	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
265	Recruits	55	258	21	2	1	0	0	
266									
267	Allowed Promotion rates:								
268	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
269	LAST rate	0	0.571429	0.182443	0.153584	0.103784	0.03619	0.103448	
270	Promotion	0	18	219	85	63	7	2	
271	Max #	0	13	294	194	132	47	9	
272	Min #	0	11	167	99	46	0	3	
273	P > Max	0	13	219	85	63	7	2	
274	Final P	0	13	219	99	63	7	3	
275									
276	Constrained								
277	Yes/No	1	1	1	0	1	1	0	
278									
279	Demotions:								
280	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
281	Demoted	16	4	3	1	0	0	0	
282									
283	Temporary End of Year Values:								
284	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	

	AC	AD	AE	AF	AG	AH	AI	AJ	AK
285	Inventory	73	1098	990	841	537	54	30	
286	Billets	73	1098	990	827	537	54	29	
287									
288	End of period vacancy vector v(t):								
289	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
290	v(t)	0	0	0	-14	0	0	-1	
291									
292									

	AL	AM	AN	AO	AP	AQ	AR	AS	AT
244	**Second Calculation of Vacancy Model (Year 1)**								
245									
246									
247	Total Vacancies (v(t-1) + e(t-1) w + m):								
248	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
249	TV	53.9997	44.032	154.986	22.0176	55.9969	4.9975	1.9996	
250									
251	Vacancy Vector v(t): Equals number of vacancies that appear in each paygrade.								
252	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
253	Vacancy	72.13974	279.7803	244.1183	87.84927	63.65015	6.9971	1.9996	
254									
255	Recruitment Vector (Rj): From the vacancy model.								
256	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
257	Recruits	56	258	21	2	1	0	0	
258	Min Rec	18	82						
259	Max Rec	107	493						
260	R > Max	56	258						
261	Final Rec	56	258						
262									
263	Recruitment Vector (Rj): From vacancy model with recruitment constraints.								
264	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
265	Recruits	56	258	21	2	1	0	0	
266									
267	Allowed Promotion rates:								
268	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
269	LAST rate	0	0.571429	0.182443	0.153584	0.103784	0.03619	0.103448	
270	Promotion	0	18	220	85	63	7	2	
271	Max #	0	13	294	194	132	47	9	
272	Min #	0	11	167	99	46	0	3	
273	P > Max	0	13	220	85	63	7	2	
274	Final P	0	13	220	99	63	7	3	
275									
276	Constrained								
277	Yes/No	1	1	1	0	1	1	0	
278									
279	Demotions:								
280	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
281	Demoted	16	4	3	1	0	0	0	
282									
283	Temporary End of Year Values:								
284	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	

	AL	AM	AN	AO	AP	AQ	AR	AS	AT
285	Inventory	74	1097	991	841	537	54	30	
286	Billets	73	1098	990	827	537	54	29	
287									
288	End of period vacancy vector v(t):								
289	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
290	v(t)	-1	1	-1	-14	0	0	-1	
291									
292									

	AU	AV	AW	AX	AY	AZ	BA	BB	BC
244	First Calculation of Vacancy Model (Year 1)								
245									
246									
247	Total Vacancies (v(t-1) + e(t-1) w + m):								
248	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
249	TV	57.9997	40.032	139.986	22.0176	55.9969	3.9975	1.9996	
250									
251	Vacancy Vector v(t): Equals number of vacancies that appear in each paygrade.								
252	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
253	Vacancy	74.96307	261.6322	227.7058	86.65803	62.653	5.9971	1.9996	
254									
255	Recruitment Vector (Rj): From the vacancy model.								
256	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
257	Recruits	58	241	20	2	1	0	0	
258	Min Rec	19	81						
259	Max Rec	116	484						
260	R > Max	58	241						
261	Final Rec	58	241						
262									
263	Recruitment Vector (Rj): From vacancy model with recruitment constraints.								
264	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
265	Recruits	58	241	20	2	1	0	0	
266									
267	Allowed Promotion rates:								
268	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
269	LAST rate	0	0.571429	0.182443	0.153584	0.103784	0.03619	0.103448	
270	Promotion	0	17	205	84	62	6	2	
271	Max #	0	13	294	194	132	47	9	
272	Min #	0	11	167	99	46	0	3	
273	P > Max	0	13	205	84	62	6	2	
274	Final P	0	13	205	99	62	6	3	
275									
276	Constrained								
277	Yes/No	1	1	1	0	1	1	0	
278									
279	Demotions:								
280	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
281	Demoted	17	4	3	1	0	0	0	
282									
283	Temporary End of Year Values:								
284	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	

	AU	AV	AW	AX	AY	AZ	BA	BB	BC
285	Inventory	77	1094	975	842	537	53	30	
286	Billets	73	1098	990	827	537	54	29	
287									
288	End of period vacancy vector v(t):								
289	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
290	v(t)	-4	4	15	-15	0	1	-1	
291									
292									

	BD	BE	BF	BG	BH	BI	BJ	BK	BL
244	**MULTIPLIER ANALYSIS**								
245									
246									
247	Promotion Multiplier:								
248	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
249	1980	N/A	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	
250	1981	N/A	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	
251	1982	N/A	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	
252	1983	N/A	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	
253	1984	N/A	0.942006	1.109956	1.121429	1.150531	1.195594	1.099345	
254	1985	N/A	0.893187	1.167832	1.193139	1.133011	1.109002	0.97502	
255	1986	N/A	0.87548	1.201879	1.151184	1.162174	1.11932	1.116271	
256	1987	N/A	0.930041	1.227148	1.090121	1.127404	1.090525	0.961783	
257									
258	Attrition Multiplier:								
259	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
260	1980	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	
261	1981	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	
262	1982	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	
263	1983	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	
264	1984	1.330003	1.133388	0.945179	1.194493	1.170203	1.075013	1.102414	
265	1985	1.349194	1.196344	0.923835	1.070122	1.329361	0.976115	1.048074	
266	1986	1.286638	1.195812	1.022491	1.046867	1.147193	1.170859	1.031292	
267	1987	1.401043	1.140836	0.981254	0.961538	1.130245	1.085689	0.990757	
268									
269	Recruitment Multiplier:								
270	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
271	1980	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	
272	1981	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	
273	1982	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	
274	1983	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	
275	1984	0.537527	0.627766	0.911714	1.012923	0.802089	0.736227	0	
276	1985	0.308626	0.617092	0.892719	0.819957	1.148709	0	0	
277	1986	0.794997	0.665894	0.668922	1.371393	0.967216	0	0	
278	1987	0.330788	0.627559	0.829697	0.9846	1.324927	0	0	
279									
280	Demotion Multiplier:								
281	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
282	1980	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	N/A	
283	1981	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	N/A	
284	1982	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	N/A	

	BD	BE	BF	BG	BH	BI	BJ	BK	BL
285	1983	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	N/A	
286	1984	1.117596	1.21875	0.987695	1.19143	0	0	N/A	
287	1985	1.033994	1.410823	0.911616	1.151289	0	0	N/A	
288	1986	1.002713	1.162148	1.152164	0.80245	0	0	N/A	
289	1987	1.029879	1.328189	1.318347	0	0	0	N/A	
290									
291									
292									

	A	B	C	D	E	F	G	H	I	J
293	**RESULTS FOR FISCAL YEAR**					**1990**				
294										
295										
296	**Beginning of Year Values:**									
297	Paygrade:		E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	Total
298	Inventories: e(t-1)		73	1098	990	841	537	54	30	3623
299	Billets: n(t-1)		73	1098	990	827	537	54	29	3608
300	Inventory TIS:		2.71944	4.32055	7.84145	12.0002	15.3187	18.6934	23.713	N/A
301	Attrition Rate: w		0.9	0.2465	0.1107	0.0595	0.2015	0.3036	0.3103	N/A
302										
303										
304	**Flows for fiscal year**			**1990**						
305	Values are number moved to that paygrade during the fiscal year.									
306	Paygrade:		E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	Total
307	Promotions:		0	42	211	133	104	26	5	521
308	Recruitment:		84	455	20	3	2	0	0	564
309	Attrition:		66	271	110	50	108	16	9	630
310	Demotions:		24	7	3	1	0	0	0	35
311										
312										
313	**Time In Service Mean Values:**									
314	Values are mean TIS for those moved to that paygrade during the year.									
315	See Flows box above for number moved.									
316	Paygrade:		E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
317	TISADV: Promotees		0	2.5395	5.45111	8.61635	13.6077	17.0491	19.22	
318	TIS: Attritees		3.38392	5.03654	8.00472	12.3411	17.9305	20.3307	24.4663	
319	TIS: Recruited		1.69963	2.73921	5.65972	12.4803	14.3562	13.7783	23.713	
320	TIS: Demoted		4.49818	10.1495	13.93	14.5741	18.6934	23.713	0	
321										
322										
323	**End of Year Values:**									
324	Paygrade:		E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	Total
325	Inventory: e(t)		73	1096	974	821	508	59	26	3557
326	Billets: n(t)		73	1096	974	821	520	59	29	3572
327	Inventory TIS:		1.15406	3.7746	7.93702	12.0586	15.1136	18.0394	23.3959	N/A
328										
329	diff		0	0	0	0	12	0	3	
330										

	K	L	M	N	O	P	Q	R	S
293	**SECOND YEAR CALCULATIONS**								
294									
295									
296	Total Vacancies (v(t-1) + e(t-1) w + m):								
297	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
298	TV	75.7	258.657	94.593	17.0395	91.2055	18.3944	8.309	
299									
300	Vacancy Vector v(t): Equals number of vacancies that appear in each paygrade.								
301	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
302	Vacancy	107.7018	493.575	234.4353	137.0294	118.7273	26.7034	8.309	
303									
304	Multipliers for those promoted: TISADV C values								
305	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
306	C value	N/A	0.92	1.192124	1.128383	1.148081	1.11296	1.028168	
307									
308	Multipliers for those attrited: TIS_ATT C values								
309	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
310	C value	1.349265	1.165717	0.978721	1.028404	1.170499	1.087589	1.031768	
311									
312	Multipliers for those recruited: TIS_REC C values								
313	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
314	C value	0.624991	0.633995	0.849297	1.040006	0.937169	0.737065	1	
315									
316	Multipliers for those demoted: TIS_DEM C values								
317	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
318	C value	1.041113	1.294343	1.160814	0.951393	1	1	N/A	
319									
320									
321									
322									
323									
324									
325									
326									
327									
328									
329									
330									

	T	U	V	W	X	Y	Z	AA	AB
293	**MORE CALCULATIONS (Year 2)**								
294									
295									
296	Recruitment Vector (Rj): From the vacancy model.								
297	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
298	Recruits	84	455	20	3	2	0	0	
299	Min Rec	16	84						
300	Max Rec	94	506						
301	R > Max	84	455						
302	Final Rec	84	455						
303									
304	Allowed Promotion rates:								
305	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
306	LAST rate	0	0.619048	0.173259	0.103774	0.073598	0.012939	0.050847	
307	Promotion	0	32	211	133	117	26	8	
308	Max #	0	49	245	152	104	34	5	
309	Min #	0	42	135	53	20	0	0	
310	P > Max	0	32	211	133	104	26	5	
311	Final P	0	42	211	133	104	26	5	
312									
313									
314	Promotion TISADV Regression: even weights.								
315	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
316	Slope	N/A	0.823268	2.497764	0.935978	1.092934	-0.30458	7.166453	
317	Intercept	N/A	0.300668	-5.3406	1.276921	0.492223	20.08525	-109.952	
318	Rsquared	N/A	0.846397	0.948142	0.842668	0.942416	0.021775	0.784408	
319									
320	Attrition TIS Regression: even weights.								
321	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
322	Slope	1.697659	0.981362	1.233135	-0.37655	-2.31002	5.256065	1.781628	
323	Intercept	-1.23276	0.748915	-1.66485	14.12244	49.10986	-74.9804	-16.7951	
324	Rsquared	0.931815	0.514065	0.927498	0.2291	0.30904	0.454833	0.579509	
325									
326	Recruited TIS Regression: even weights.								
327	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
328	Slope	-1.27368	0.69439	0.250882	2.60716	9.07425	1.331233	0	
329	Intercept	6.118772	-0.24177	3.611115	-15.2465	-112.304	-20.5818	0	
330	Rsquared	0.271277	0.565022	0.065626	0	0	0	0	
331									
332	Demoted TIS Regression: even weights.								
333	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	

	T	U	V	W	X	Y	Z	AA	AB
334	Slope	0.237956	1.376973	3.999153	-29.0956	0	0	0	
335	Intercept	3.266771	-0.60932	-28.4126	418.7741	0	0	0	
336	Rsquared	0.042413	0.607528	0	0	0	0	0	
337									
338									
339									
340									
341									
342									

	AC	AD	AE	AF	AG	AH	AI	AJ	AK
293	**Third Calculation of Vacancy Model (Year 2)**								
294									
295									
296	Total Vacancies (v(t-1) + e(t-1) w + m):								
297	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
298	TV	75.7	258.657	94.593	17.0395	91.2055	18.3944	8.309	
299									
300	Vacancy Vector v(t): Equals number of vacancies that appear in each paygrade.								
301	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
302	Vacancy	107.7018	493.575	234.4353	137.0294	118.7273	26.7034	8.309	
303									
304	Recruitment Vector (Rj): From the vacancy model.								
305	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
306	Recruits	84	455	20	3	2	0	0	
307	Min Rec	16	84						
308	Max Rec	94	506						
309	R > Max	84	455						
310	Final Rec	84	455						
311									
312	Recruitment Vector (Rj): From vacancy model with recruitment constraints.								
313	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
314	Recruits	84	455	20	3	2	0	0	
315									
316	Allowed Promotion rates:								
317	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
318	LAST rate	0	0.619048	0.173259	0.103774	0.073598	0.012939	0.050847	
319	Promotion	0	32	211	133	117	26	8	
320	Max #	0	49	245	152	104	34	5	
321	Min #	0	42	135	53	20	0	0	
322	P > Max	0	32	211	133	104	26	5	
323	Final P	0	42	211	133	104	26	5	
324									
325	Constrained								
326	Yes/No	1	1	1	1	0	1	0	
327									
328	Demotions:								
329	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
330	Demoted	24	7	3	1	0	0	0	
331									
332	Temporary End of Year Values:								
333	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	

	AC	AD	AE	AF	AG	AH	AI	AJ	AK
334	Inventory	73	1096	974	821	508	59	26	
335	Billets	73	1096	974	821	520	59	29	
336									
337	End of period vacancy vector v(t):								
338	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
339	v(t)	0	0	0	0	12	0	3	
340									
341									
342									

	AL	AM	AN	AO	AP	AQ	AR	AS	AT
293	**Second Calculation of Vacancy Model (Year 2)**								
294									
295									
296	Total Vacancies (v(t-1) + e(t-1) w + m):								
297	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
298	TV	74.7	260.657	93.593	14.0395	91.2055	18.3944	8.309	
299									
300	Vacancy Vector v(t): Equals number of vacancies that appear in each paygrade.								
301	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
302	Vacancy	106.5814	491.7178	230.4264	133.9527	118.7012	26.7034	8.309	
303									
304	Recruitment Vector (Rj): From the vacancy model.								
305	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
306	Recruits	83	453	20	3	2	0	0	
307	Min Rec	15	85						
308	Max Rec	93	507						
309	R > Max	83	453						
310	Final Rec	83	453						
311									
312	Recruitment Vector (Rj): From vacancy model with recruitment constraints.								
313	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
314	Recruits	83	453	20	3	2	0	0	
315									
316	Allowed Promotion rates:								
317	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
318	LAST rate	0	0.619048	0.173259	0.103774	0.073598	0.012939	0.050847	
319	Promotion	0	32	207	130	117	26	8	
320	Max #	0	49	245	152	104	34	5	
321	Min #	0	42	135	53	20	0	0	
322	P > Max	0	32	207	130	104	26	5	
323	Final P	0	42	207	130	104	26	5	
324									
325	Constrained								
326	Yes/No	1	1	1	1	0	1	0	
327									
328	Demotions:								
329	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
330	Demoted	24	7	3	1	0	0	0	
331									
332	Temporary End of Year Values:								
333	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	

	AL	AM	AN	AO	AP	AQ	AR	AS	AT
334	Inventory	72	1098	973	818	508	59	26	
335	Billets	73	1096	974	821	520	59	29	
336									
337	End of period vacancy vector v(t):								
338	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
339	v(t)	1	-2	1	3	12	0	3	
340									
341									
342									

	AU	AV	AW	AX	AY	AZ	BA	BB	BC
293	First Calculation of Vacancy Model (Year 2)								
294									
295									
296	Total Vacancies (v(t-1) + e(t-1) w + m):								
297	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
298	TV	65.7	268.657	93.593	30.0395	91.2055	21.3944	8.309	
299									
300	Vacancy Vector v(t): Equals number of vacancies that appear in each paygrade.								
301	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
302	Vacancy	99.10528	515.2215	249.491	153.2751	121.8265	29.7034	8.309	
303									
304	Recruitment Vector (Rj): From the vacancy model.								
305	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
306	Recruits	77	475	22	3	2	0	0	
307	Min Rec	14	86						
308	Max Rec	84	516						
309	R > Max	77	475						
310	Final Rec	77	475						
311									
312	Recruitment Vector (Rj): From vacancy model with recruitment constraints.								
313	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
314	Recruits	77	475	22	3	2	0	0	
315									
316	Allowed Promotion rates:								
317	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
318	LAST rate	0	0.619048	0.173259	0.103774	0.073598	0.012939	0.050847	
319	Promotion	0	33	225	149	120	29	8	
320	Max #	0	49	245	152	104	34	5	
321	Min #	0	42	135	53	20	0	0	
322	P > Max	0	33	225	149	104	29	5	
323	Final P	0	42	225	149	104	29	5	
324									
325	Constrained								
326	Yes/No	1	1	1	1	0	1	0	
327									
328	Demotions:								
329	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
330	Demoted	22	7	3	1	0	0	0	
331									
332	Temporary End of Year Values:								
333	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	

	AU	AV	AW	AX	AY	AZ	BA	BB	BC
334	Inventory	64	1104	974	837	505	62	26	
335	Billets	73	1096	974	821	520	59	29	
336									
337	End of period vacancy vector v(t):								
338	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
339	v(t)	9	-8	0	-16	15	-3	3	
340									
341									
342									

	A	B	C	D	E	F	G	H	I	J
343	**RESULTS FOR FISCAL YEAR**					**1991**				
344										
345										
346	**Beginning of Year Values:**									
347	Paygrade:		E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	Total
348	Inventories: e(t-1)		73	1096	974	821	508	59	26	3557
349	Billets: n(t-1)		73	1096	974	821	520	59	29	3572
350	Inventory TIS:		1.15406	3.7746	7.93702	12.0586	15.1136	18.0394	23.3959	N/A
351	Attrition Rate: w		0.2759	0.2178	0.084	0.0344	0.1365	0.2364	0.1034	N/A
352										
353										
354	**Flows for fiscal year**			**1991**						
355	Values are number moved to that paygrade during the fiscal year.									
356	Paygrade:		E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	Total
357	Promotions:		0	38	214	131	103	22	8	516
358	Recruitment:		40	450	21	3	2	0	0	516
359	Attrition:		20	239	82	28	69	14	3	455
360	Demotions:		11	7	3	1	0	0	0	22
361										
362										
363	**Time In Service Mean Values:**									
364	Values are mean TIS for those moved to that paygrade during the year.									
365	See Flows box above for number moved.									
366	Paygrade:		E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
367	TISADV: Promotees		0	1.25077	4.08747	8.7058	13.6715	16.8208	18.5476	
368	TIS: Attritees		0.72644	4.40012	8.12258	12.4011	17.6904	19.6195	24.1391	
369	TIS: Recruited		0.72128	2.39308	6.74089	12.541	14.164	13.2962	23.3959	
370	TIS: Demoted		3.92979	10.2732	13.9978	14.3789	18.0394	23.3959	0	
371										
372										
373	**End of Year Values:**									
374	Paygrade:		E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	Total
375	Inventory: e(t)		66	1127	992	822	521	59	31	3618
376	Billets: n(t)		67	1126	992	822	521	59	31	3618
377	Inventory TIS:		1.65556	3.54545	7.72632	12.1438	15.2113	17.7683	22.8147	N/A
378										
379	diff		1	-1	0	0	0	0	0	
380										

	K	L	M	N	O	P	Q	R	S
343	**THIRD YEAR CALCULATIONS**								
344									
345									
346	Total Vacancies (v(t-1) + e(t-1) w + m):								
347	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
348	TV	20.1407	262.7088	99.816	29.2424	81.342	14.9476	7.6884	
349									
350	Vacancy Vector v(t): Equals number of vacancies that appear in each paygrade.								
351	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
352	Vacancy	51.82106	488.6175	238.193	135.5905	104.837	22.636	7.6884	
353									
354	Multipliers for those promoted: TISADV C values								
355	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
356	C value	N/A	0.92	1.192124	1.128383	1.148081	1.11296	1.028168	
357									
358	Multipliers for those attrited: TIS_ATT C values								
359	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
360	C value	1.349265	1.165717	0.978721	1.028404	1.170499	1.087589	1.031768	
361									
362	Multipliers for those recruited: TIS_REC C values								
363	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
364	C value	0.624991	0.633995	0.849297	1.040006	0.937169	0.737065	1	
365									
366	Multipliers for those demoted: TIS_DEM C values								
367	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
368	C value	1.041113	1.294343	1.160814	0.951393	1	1	N/A	
369									
370									
371									
372									
373									
374									
375									
376									
377									
378									
379									
380									

	T	U	V	W	X	Y	Z	AA	AB
343	MORE CALCULATIONS (Year 3)								
344									
345									
346	Recruitment Vector (Rj): From the vacancy model.								
347	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
348	Recruits	40	450	21	3	2	0	0	
349	Min Rec	8	92						
350	Max Rec	49	551						
351	R > Max	40	450						
352	Final Rec	40	450						
353									
354	Allowed Promotion rates:								
355	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
356	LAST rate	0	0.575342	0.192168	0.134343	0.123662	0.048417	0.092593	
357	Promotion	0	32	214	131	103	22	8	
358	Max #	0	46	265	180	143	50	8	
359	Min #	0	38	156	82	60	0	3	
360	P > Max	0	32	214	131	103	22	8	
361	Final P	0	38	214	131	103	22	8	
362									
363									
364	Promotion TISADV Regression: even weights.								
365	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
366	Slope	N/A	0.823268	2.497764	0.935978	1.092934	-0.30458	7.166453	
367	Intercept	N/A	0.300668	-5.3406	1.276921	0.492223	20.08525	-109.952	
368	Rsquared	N/A	0.846397	0.948142	0.842668	0.942416	0.021775	0.784408	
369									
370	Attrition TIS Regression: even weights.								
371	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
372	Slope	1.697659	0.981362	1.233135	-0.37655	-2.31002	5.256065	1.781628	
373	Intercept	-1.23276	0.748915	-1.66485	14.12244	49.10986	-74.9804	-16.7951	
374	Rsquared	0.931815	0.514065	0.927498	0.2291	0.30904	0.454833	0.579509	
375									
376	Recruited TIS Regression: even weights.								
377	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
378	Slope	-1.27368	0.69439	0.250882	2.60716	9.07425	1.331233	0	
379	Intercept	6.118772	-0.24177	3.611115	-15.2465	-112.304	-20.5818	0	
380	Rsquared	0.271277	0.565022	0.065626	0	0	0	0	
381									
382	Demoted TIS Regression: even weights.								
383	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	

	T	U	V	W	X	Y	Z	AA	AB
384	Slope	0.237956	1.376973	3.999153	-29.0956	0	0	0	
385	Intercept	3.266771	-0.60932	-28.4126	418.7741	0	0	0	
386	Rsquared	0.042413	0.607528	0	0	0	0	0	
387									
388									
389									
390									
391									
392									

	AC	AD	AE	AF	AG	AH	AI	AJ	AK
343	**Third Calculation of Vacancy Model (Year 3)**								
344									
345									
346	Total Vacancies (v(t-1) + e(t-1) w + m):								
347	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
348	TV	21.1407	261.7088	99.816	29.2424	81.342	14.9476	7.6884	
349									
350	Vacancy Vector v(t): Equals number of vacancies that appear in each paygrade.								
351	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
352	Vacancy	52.76918	487.8174	238.1815	135.5903	104.837	22.636	7.6884	
353									
354	Recruitment Vector (Rj): From the vacancy model.								
355	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
356	Recruits	41	449	21	3	2	0	0	
357	Min Rec	8	92						
358	Max Rec	50	550						
359	R > Max	41	449						
360	Final Rec	41	449						
361									
362	Recruitment Vector (Rj): From vacancy model with recruitment constraints.								
363	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
364	Recruits	41	449	21	3	2	0	0	
365									
366	Allowed Promotion rates:								
367	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
368	LAST rate	0	0.575342	0.192168	0.134343	0.123662	0.048417	0.092593	
369	Promotion	0	32	214	131	103	22	8	
370	Max #	0	46	265	180	143	50	8	
371	Min #	0	38	156	82	60	0	3	
372	P > Max	0	32	214	131	103	22	8	
373	Final P	0	38	214	131	103	22	8	
374									
375	Constrained								
376	Yes/No	1	1	1	1	1	1	1	
377									
378	Demotions:								
379	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
380	Demoted	12	7	3	1	0	0	0	
381									
382	Temporary End of Year Values:								
383	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	

	AC	AD	AE	AF	AG	AH	AI	AJ	AK
384	Inventory	68	1125	992	822	521	59	31	
385	Billets	67	1126	992	822	521	59	31	
386									
387	End of period vacancy vector v(t):								
388	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
389	v(t)	-1	1	0	0	0	0	0	
390									
391									
392									

	AL	AM	AN	AO	AP	AQ	AR	AS	AT
343	**Second Calculation of Vacancy Model (Year 3)**								
344									
345									
346	Total Vacancies (v(t-1) + e(t-1) w + m):								
347	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
348	TV	20.1407	262.7088	99.816	29.2424	81.342	14.9476	7.6884	
349									
350	Vacancy Vector v(t): Equals number of vacancies that appear in each paygrade.								
351	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
352	Vacancy	51.82106	488.6175	238.193	135.5905	104.837	22.636	7.6884	
353									
354	Recruitment Vector (Rj): From the vacancy model.								
355	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
356	Recruits	40	450	21	3	2	0	0	
357	Min Rec	8	92						
358	Max Rec	49	551						
359	R > Max	40	450						
360	Final Rec	40	450						
361									
362	Recruitment Vector (Rj): From vacancy model with recruitment constraints.								
363	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
364	Recruits	40	450	21	3	2	0	0	
365									
366	Allowed Promotion rates:								
367	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
368	LAST rate	0	0.575342	0.192168	0.134343	0.123662	0.048417	0.092593	
369	Promotion	0	32	214	131	103	22	8	
370	Max #	0	46	265	180	143	50	8	
371	Min #	0	38	156	82	60	0	3	
372	P > Max	0	32	214	131	103	22	8	
373	Final P	0	38	214	131	103	22	8	
374									
375	Constrained								
376	Yes/No	1	1	1	1	1	1	1	
377									
378	Demotions:								
379	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
380	Demoted	11	7	3	1	0	0	0	
381									
382	Temporary End of Year Values:								
383	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	

	AL	AM	AN	AO	AP	AQ	AR	AS	AT
384	Inventory	66	1127	992	822	521	59	31	
385	Billets	67	1126	992	822	521	59	31	
386									
387	End of period vacancy vector v(t):								
388	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
389	v(t)	1	-1	0	0	0	0	0	
390									
391									
392									

	AU	AV	AW	AX	AY	AZ	BA	BB	BC
343	First Calculation of Vacancy Model (Year 3)								
344									
345									
346	Total Vacancies (v(t-1) + e(t-1) w + m):								
347	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
348	TV	14.1407	268.7088	99.816	29.2424	82.342	13.9476	7.6884	
349									
350	Vacancy Vector v(t): Equals number of vacancies that appear in each paygrade.								
351	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
352	Vacancy	46.13307	493.4298	238.2749	135.6044	104.8501	21.636	7.6884	
353									
354	Recruitment Vector (Rj): From the vacancy model.								
355	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
356	Recruits	36	454	21	3	2	0	0	
357	Min Rec	7	93						
358	Max Rec	44	556						
359	R > Max	36	454						
360	Final Rec	36	454						
361									
362	Recruitment Vector (Rj): From vacancy model with recruitment constraints.								
363	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
364	Recruits	36	454	21	3	2	0	0	
365									
366	Allowed Promotion rates:								
367	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
368	LAST rate	0	0.575342	0.192168	0.134343	0.123662	0.048417	0.092593	
369	Promotion	0	32	214	131	103	21	8	
370	Max #	0	46	265	180	143	50	8	
371	Min #	0	38	156	82	60	0	3	
372	P > Max	0	32	214	131	103	21	8	
373	Final P	0	38	214	131	103	21	8	
374									
375	Constrained								
376	Yes/No	1	1	1	1	1	1	1	
377									
378	Demotions:								
379	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
380	Demoted	10	7	3	1	0	0	0	
381									
382	Temporary End of Year Values:								
383	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	

	AU	AV	AW	AX	AY	AZ	BA	BB	BC
384	Inventory	61	1132	992	822	522	58	31	
385	Billets	67	1126	992	822	521	59	31	
386									
387	End of period vacancy vector v(t):								
388	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
389	v(t)	6	-6	0	0	-1	1	0	
390									
391									
392									

	A	B	C	D	E	F	G	H	I	J
393	**RESULTS FOR FISCAL YEAR**					**1992**				
394										
395										
396	**Beginning of Year Values:**									
397	Paygrade:		E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	Total
398	Inventories: e(t-1)		66	1127	992	822	521	59	31	3618
399	Billets: n(t-1)		67	1126	992	822	521	59	31	3618
400	Inventory TIS:		1.65556	3.54545	7.72632	12.1438	15.2113	17.7683	22.8147	N/A
401	Attrition Rate: w		0.27586	0.1689	0.0582	0.0388	0.0731	0.2203	0.0968	N/A
402										
403										
404	**Flows for fiscal year**			**1992**						
405	Values are number moved to that paygrade during the fiscal year.									
406	Paygrade:		E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	Total
407	Promotions:		0	31	164	34	62	16	5	362
408	Recruitment:		35	313	11	1	1	0	0	361
409	Attrition:		18	190	58	32	38	13	3	352
410	Demotions:		10	5	2	1	0	0	0	18
411										
412										
413	**Time In Service Mean Values:**									
414	Values are mean TIS for those moved to that paygrade during the year.									
415	See Flows box above for number moved.									
416	Paygrade:		E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
417	TISADV: Promotees		0	1.66364	3.51509	8.50859	13.7646	16.9296	18.2688	
418	TIS: Attritees		1.57782	4.13299	7.86275	12.4887	17.8049	19.3246	23.5395	
419	TIS: Recruited		1.03471	2.24779	6.56194	12.6296	14.2556	13.0964	22.8147	
420	TIS: Demoted		3.69121	10.0005	14.0967	14.472	17.7683	22.8147	0	
421										
422										
423	**End of Year Values:**									
424	Paygrade:		E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	Total
425	Inventory: e(t)		62	1112	1022	812	529	57	33	3627
426	Billets: n(t)		62	1112	990	814	508	57	32	3575
427	Inventory TIS:		1.92614	3.74568	7.79412	12.5231	15.684	17.8533	22.9085	N/A
428										
429	diff		0	0	-32	2	-21	0	-1	
430										

	K	L	M	N	O	P	Q	R	S
393	**FOURTH YEAR CALCULATIONS**								
394									
395									
396	Total Vacancies (v(t-1) + e(t-1) w + m):								
397	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
398	TV	23.20676	217.3503	55.7344	23.8936	25.0851	11.9977	4.0008	
399									
400	Vacancy Vector v(t): Equals number of vacancies that appear in each paygrade.								
401	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
402	Vacancy	45.23623	339.7683	124.8488	66.32064	41.43978	15.9985	4.0008	
403									
404	Multipliers for those promoted: TISADV C values								
405	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
406	C value	N/A	0.92	1.192124	1.128383	1.148081	1.11296	1.028168	
407									
408	Multipliers for those attrited: TIS_ATT C values								
409	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
410	C value	1.349265	1.165717	0.978721	1.028404	1.170499	1.087589	1.031768	
411									
412	Multipliers for those recruited: TIS_REC C values								
413	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
414	C value	0.624991	0.633995	0.849297	1.040006	0.937169	0.737065	1	
415									
416	Multipliers for those demoted: TIS_DEM C values								
417	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
418	C value	1.041113	1.294343	1.160814	0.951393	1	1	N/A	
419									
420									
421									
422									
423									
424									
425									
426									
427									
428									
429									
430									

	T	U	V	W	X	Y	Z	AA	AB
393	**MORE CALCULATIONS (Year 4)**								
394									
395									
396	Recruitment Vector (Rj): From the vacancy model.								
397	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
398	Recruits	35	313	11	1	1	0	0	
399	Min Rec	10	90						
400	Max Rec	60	540						
401	R > Max	35	313						
402	Final Rec	35	313						
403									
404	Allowed Promotion rates:								
405	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
406	LAST rate	0	0.520548	0.195255	0.134497	0.125457	0.043307	0.135593	
407	Promotion	0	22	112	64	41	16	4	
408	Max #	0	38	276	183	144	49	11	
409	Min #	0	31	164	84	62	0	5	
410	P > Max	0	22	112	64	41	16	4	
411	Final P	0	31	164	84	62	16	5	
412									
413									
414	Promotion TISADV Regression: even weights.								
415	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
416	Slope	N/A	0.823268	2.497764	0.935978	1.092934	-0.30458	7.166453	
417	Intercept	N/A	0.300668	-5.3406	1.276921	0.492223	20.08525	-109.952	
418	Rsquared	N/A	0.846397	0.948142	0.842668	0.942416	0.021775	0.784408	
419									
420	Attrition TIS Regression: even weights.								
421	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
422	Slope	1.697659	0.981362	1.233135	-0.37655	-2.31002	5.256065	1.781628	
423	Intercept	-1.23276	0.748915	-1.66485	14.12244	49.10986	-74.9804	-16.7951	
424	Rsquared	0.931815	0.514065	0.927498	0.2291	0.30904	0.454833	0.579509	
425									
426	Recruited TIS Regression: even weights.								
427	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
428	Slope	-1.27368	0.69439	0.250882	2.60716	9.07425	1.331233	0	
429	Intercept	6.118772	-0.24177	3.611115	-15.2465	-112.304	-20.5818	0	
430	Rsquared	0.271277	0.565022	0.065626	0	0	0	0	
431									
432	Demoted TIS Regression: even weights.								
433	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	

	T	U	V	W	X	Y	Z	AA	AB
434	Slope	0.237956	1.376973	3.999153	-29.0956	0	0	0	
435	Intercept	3.266771	-0.60932	-28.4126	418.7741	0	0	0	
436	Rsquared	0.042413	0.607528	0	0	0	0	0	
437									
438									
439									
440									
441									
442									

	AC	AD	AE	AF	AG	AH	AI	AJ	AK
393	**Third Calculation of Vacancy Model (Year 4)**								
394									
395									
396	Total Vacancies (v(t-1) + e(t-1) w + m):								
397	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
398	TV	22.20676	217.3503	55.7344	23.8936	25.0851	11.9977	4.0008	
399									
400	Vacancy Vector v(t): Equals number of vacancies that appear in each paygrade.								
401	Paygrade	E-2/3	E-4	F-5	E-6	E-7	E-8	E-9	
402	Vacancy	44.22144	339.5403	124.8455	66.3206	41.43978	15.9985	4.0008	
403									
404	Recruitment Vector (Rj): From the vacancy model.								
405	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
406	Recruits	34	313	11	1	1	0	0	
407	Min Rec	10	90						
408	Max Rec	59	541						
409	R > Max	34	313						
410	Final Rec	34	313						
411									
412	Recruitment Vector (Rj): From vacancy model with recruitment constraints.								
413	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
414	Recruits	34	313	11	1	1	0	0	
415									
416	Allowed Promotion rates:								
417	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
418	LAST rate	0	0.520548	0.195255	0.134497	0.125457	0.043307	0.135593	
419	Promotion	0	22	112	64	41	16	4	
420	Max #	0	38	276	183	144	49	11	
421	Min #	0	31	164	84	62	0	5	
422	P > Max	0	22	112	64	41	16	4	
423	Final P	0	31	164	84	62	16	5	
424									
425	Constrained								
426	Yes/No	1	1	0	0	0	1	0	
427									
428	Demotions:								
429	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
430	Demoted	10	5	2	1	0	0	0	
431									
432	Temporary End of Year Values:								
433	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	

	AC	AD	AE	AF	AG	AH	AI	AJ	AK
434	Inventory	61	1112	1022	812	529	57	33	
435	Billets	62	1112	990	814	508	57	32	
436									
437	End of period vacancy vector v(t):								
438	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
439	v(t)	1	0	-32	2	-21	0	-1	
440									
441									
442									

	AL	AM	AN	AO	AP	AQ	AR	AS	AT
393	**Second Calculation of Vacancy Model (Year 4)**								
394									
395									
396	Total Vacancies (v(t-1) + e(t-1) w + m):								
397	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
398	TV	26.20676	216.3503	55.7344	23.8936	25.0851	11.9977	4.0008	
399									
400	Vacancy Vector v(t): Equals number of vacancies that appear in each paygrade.								
401	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
402	Vacancy	48.21391	339.4242	124.8438	66.32057	41.43978	15.9985	4.0008	
403									
404	Recruitment Vector (Rj): From the vacancy model.								
405	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
406	Recruits	38	313	11	1	1	0	0	
407	Min Rec	11	89						
408	Max Rec	65	535						
409	R > Max	38	313						
410	Final Rec	38	313						
411									
412	Recruitment Vector (Rj): From vacancy model with recruitment constraints.								
413	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
414	Recruits	38	313	11	1	1	0	0	
415									
416	Allowed Promotion rates:								
417	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
418	LAST rate	0	0.520548	0.195255	0.134497	0.125457	0.043307	0.135593	
419	Promotion	0	22	112	64	41	16	4	
420	Max #	0	38	276	183	144	49	11	
421	Min #	0	31	164	84	62	0	5	
422	P > Max	0	22	112	64	41	16	4	
423	Final P	0	31	164	84	62	16	5	
424									
425	Constrained								
426	Yes/No	1	1	0	0	0	1	0	
427									
428	Demotions:								
429	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
430	Demoted	11	5	2	1	0	0	0	
431									
432	Temporary End of Year Values:								
433	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	

	AL	AM	AN	AO	AP	AQ	AR	AS	AT
434	Inventory	66	1111	1022	812	529	57	33	
435	Billets	62	1112	990	814	508	57	32	
436									
437	End of period vacancy vector v(t):								
438	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
439	v(t)	-4	1	-32	2	-21	0	-1	
440									
441									
442									

	AU	AV	AW	AX	AY	AZ	BA	BB	BC
393	**First Calculation of Vacancy Model (Year 4)**								
394									
395									
396	Total Vacancies (v(t-1) + e(t-1) w + m):								
397	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
398	TV	14.20676	175.3503	55.7344	23.8936	25.0851	10.9977	4.0008	
399									
400	Vacancy Vector v(t): Equals number of vacancies that appear in each paygrade.								
401	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
402	Vacancy	33.24578	293.6457	123.2228	65.31884	40.44425	14.9985	4.0008	
403									
404	Recruitment Vector (Rj): From the vacancy model.								
405	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
406	Recruits	26	270	11	1	1	0	0	
407	Min Rec	9	91						
408	Max Rec	53	547						
409	R > Max	26	270						
410	Final Rec	26	270						
411									
412	Recruitment Vector (Rj): From vacancy model with recruitment constraints.								
413	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
414	Recruits	26	270	11	1	1	0	0	
415									
416	Allowed Promotion rates:								
417	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
418	LAST rate	0	0.520548	0.195255	0.134497	0.125457	0.043307	0.135593	
419	Promotion	0	19	111	63	40	15	4	
420	Max #	0	38	276	183	144	49	11	
421	Min #	0	31	164	84	62	0	5	
422	P > Max	0	19	111	63	40	15	4	
423	Final P	0	31	164	84	62	15	5	
424									
425	Constrained								
426	Yes/No	1	1	0	0	0	1	0	
427									
428	Demotions:								
429	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
430	Demoted	7	4	2	1	0	0	0	
431									
432	Temporary End of Year Values:								
433	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	

	AU	AV	AW	AX	AY	AZ	BA	BB	BC
434	Inventory	50	1071	1023	812	530	56	33	
435	Billets	62	1112	990	814	508	57	32	
436									
437	End of period vacancy vector v(t):								
438	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
439	v(t)	12	41	-33	2	-22	1	-1	
440									
441									
442									

	A	B	C	D	E	F	G	H	I	J
443	**RESULTS FOR FISCAL YEAR**					**1993**				
444										
445										
446	**Beginning of Year Values:**									
447	Paygrade:		E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	Total
448	Inventories: e(t-1)		62	1112	1022	812	529	57	33	3627
449	Billets: n(t-1)		62	1112	990	814	508	57	32	3575
450	Inventory TIS:		1.92614	3.74568	7.79412	12.5231	15.684	17.8533	22.9085	N/A
451	Attrition Rate: w		0.27586	0.1689	0.0582	0.0388	0.0731	0.2203	0.0968	N/A
452										
453										
454	**Flows for fiscal year**			**1993**						
455	Values are number moved to that paygrade during the fiscal year.									
456	Paygrade:		E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	Total
457	Promotions:		0	26	106	72	38	20	3	265
458	Recruitment:		33	302	10	2	1	0	0	348
459	Attrition:		17	188	59	32	39	13	3	351
460	Demotions:		9	5	1	1	0	0	0	16
461										
462										
463	**Time In Service Mean Values:**									
464	Values are mean TIS for those moved to that paygrade during the year.									
465	See Flows box above for number moved.									
466	Paygrade:		E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
467	TISADV: Promotees		0	1.8864	4.01523	8.57205	14.1792	17.4557	18.3562	
468	TIS: Attritees		2.03716	4.36641	7.94636	12.8789	18.3581	19.4171	23.6363	
469	TIS: Recruited		1.20382	2.37474	6.61952	13.0241	14.6986	13.1591	22.9085	
470	TIS: Demoted		3.89968	10.0883	14.537	14.9216	17.8533	22.9085	0	
471										
472										
473	**End of Year Values:**									
474	Paygrade:		E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	Total
475	Inventory: e(t)		61	1142	1003	816	508	61	33	3624
476	Billets: n(t)		61	1142	1003	816	508	61	33	3624
477	Inventory TIS:		2.12403	3.94857	8.19688	12.9932	16.2192	18.0371	23.3376	N/A
478										
479	diff		0	0	0	0	0	0	0	
480										

	K	L	M	N	O	P	Q	R	S
443	**FIFTH YEAR CALCULATIONS**								
444									
445									
446	Total Vacancies (v(t-1) + e(t-1) w + m):								
447	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
448	TV	21.10332	212.8168	40.4804	34.5056	17.6699	17.5571	3.1944	
449									
450	Vacancy Vector v(t): Equals number of vacancies that appear in each paygrade.								
451	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
452	Vacancy	42.34355	327.5956	117.0751	74.21548	38.78298	20.7515	3.1944	
453									
454	Multipliers for those promoted: TISADV C values								
455	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
456	C value	N/A	0.92	1.192124	1.128383	1.148081	1.11296	1.028168	
457									
458	Multipliers for those attrited: TIS_ATT C values								
459	Paygrade	E-2/3	E-4	E-5	E 6	E-7	E-8	E-9	
460	C value	1.349265	1.165717	0.978721	1.028404	1.170499	1.087589	1.031768	
461									
462	Multipliers for those recruited: TIS_REC C values								
463	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
464	C value	0.624991	0.633995	0.849297	1.040006	0.937169	0.737065	1	
465									
466	Multipliers for those demoted: TIS_DEM C values								
467	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
468	C value	1.041113	1.294343	1.160814	0.951393	1	1	N/A	
469									
470									
471									
472									
473									
474									
475									
476									
477									
478									
479									
480									

	T	U	V	W	X	Y	Z	AA	AB
443	**MORE CALCULATIONS (Year 5)**								
444									
445									
446	Recruitment Vector (Rj): From the vacancy model.								
447	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
448	Recruits	33	302	10	2	1	0	0	
449	Min Rec	10	90						
450	Max Rec	59	541						
451	R > Max	33	302						
452	Final Rec	33	302						
453									
454	Allowed Promotion rates:								
455	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
456	LAST rate	0	0.469697	0.145519	0.084677	0.075426	0.03071	0.084746	
457	Promotion	0	21	105	72	38	20	3	
458	Max #	0	32	217	138	102	43	8	
459	Min #	0	26	106	35	21	0	2	
460	P > Max	0	21	105	72	38	20	3	
461	Final P	0	26	106	72	38	20	3	
462									
463									
464	Promotion TISADV Regression: even weights.								
465	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
466	Slope	N/A	0.823268	2.497764	0.935978	1.092934	-0.30458	7.166453	
467	Intercept	N/A	0.300668	-5.3406	1.276921	0.492223	20.08525	-109.952	
468	Rsquared	N/A	0.846397	0.948142	0.842668	0.942416	0.021775	0.784408	
469									
470	Attrition TIS Regression: even weights.								
471	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
472	Slope	1.697659	0.981362	1.233135	-0.37655	-2.31002	5.256065	1.781628	
473	Intercept	-1.23276	0.748915	-1.66485	14.12244	49.10986	-74.9804	-16.7951	
474	Rsquared	0.931815	0.514065	0.927498	0.2291	0.30904	0.454833	0.579509	
475									
476	Recruited TIS Regression: even weights.								
477	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
478	Slope	-1.27368	0.69439	0.250882	2.60716	9.07425	1.331233	0	
479	Intercept	6.118772	-0.24177	3.611115	-15.2465	-112.304	-20.5818	0	
480	Rsquared	0.271277	0.565022	0.065626	0	0	0	0	
481									
482	Demoted TIS Regression: even weights.								
483	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	

	T	U	V	W	X	Y	Z	AA	AB
484	Slope	0.237956	1.376973	3.999153	-29.0956	0	0	0	
485	Intercept	3.266771	-0.60932	-28.4126	418.7741	0	0	0	
486	Rsquared	0.042413	0.607528	0	0	0	0	0	
487									
488									
489									
490									

	AC	AD	AE	AF	AG	AH	AI	AJ	AK
443	**Third Calculation of Vacancy Model (Year 5)**								
444									
445									
446	Total Vacancies (v(t-1) + e(t-1) w + m):								
447	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
448	TV	21.10332	212.8168	40.4804	34.5056	17.6699	17.5571	3.1944	
449									
450	Vacancy Vector v(t): Equals number of vacancies that appear in each paygrade.								
451	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
452	Vacancy	42.34355	327.5956	117.0751	74.21548	38.78298	20.7515	3.1944	
453									
454	Recruitment Vector (Rj): From the vacancy model.								
455	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
456	Recruits	33	302	10	2	1	0	0	
457	Min Rec	10	90						
458	Max Rec	59	541						
459	R > Max	33	302						
460	Final Rec	33	302						
461									
462	Recruitment Vector (Rj): From vacancy model with recruitment constraints.								
463	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
464	Recruits	33	302	10	2	1	0	0	
465									
466	Allowed Promotion rates:								
467	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
468	LAST rate	0	0.469697	0.145519	0.084677	0.075426	0.03071	0.084746	
469	Promotion	0	21	105	72	38	20	3	
470	Max #	0	32	217	138	102	43	8	
471	Min #	0	26	106	35	21	0	2	
472	P > Max	0	21	105	72	38	20	3	
473	Final P	0	26	106	72	38	20	3	
474									
475	Constrained								
476	Yes/No	1	1	0	1	1	1	1	
477									
478	Demotions:								
479	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
480	Demoted	9	5	1	1	0	0	0	
481									
482	Temporary End of Year Values:								
483	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	

	AC	AD	AE	AF	AG	AH	AI	AJ	AK
484	Inventory	61	1142	1003	816	508	61	33	
485	Billets	61	1142	1003	816	508	61	33	
486									
487	End of period vacancy vector v(t):								
488	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
489	v(t)	0	0	0	0	0	0	0	
490									

	AL	AM	AN	AO	AP	AQ	AR	AS	AT
443	**Second Calculation of Vacancy Model (Year 5)**								
444									
445									
446	Total Vacancies (v(t-1) + e(t-1) w + m):								
447	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
448	TV	21.10332	213.8168	40.4804	34.5056	17.6699	17.5571	3.1944	
449									
450	Vacancy Vector v(t): Equals number of vacancies that appear in each paygrade.								
451	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
452	Vacancy	42.41021	328.6237	117.0899	74.21567	38.78299	20.7515	3.1944	
453									
454	Recruitment Vector (Rj): From the vacancy model.								
455	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
456	Recruits	33	303	10	2	1	0	0	
457	Min Rec	10	90						
458	Max Rec	59	541						
459	R > Max	33	303						
460	Final Rec	33	303						
461									
462	Recruitment Vector (Rj): From vacancy model with recruitment constraints.								
463	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
464	Recruits	33	303	10	2	1	0	0	
465									
466	Allowed Promotion rates:								
467	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
468	LAST rate	0	0.469697	0.145519	0.084677	0.075426	0.03071	0.084746	
469	Promotion	0	21	105	72	38	20	3	
470	Max #	0	32	217	138	102	43	8	
471	Min #	0	26	106	35	21	0	2	
472	P > Max	0	21	105	72	38	20	3	
473	Final P	0	26	106	72	38	20	3	
474									
475	Constrained								
476	Yes/No	1	1	0	1	1	1	1	
477									
478	Demotions:								
479	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
480	Demoted	9	5	1	1	0	0	0	
481									
482	Temporary End of Year Values:								
483	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	

	AL	AM	AN	AO	AP	AQ	AR	AS	AT
484	Inventory	61	1143	1003	816	508	61	33	
485	Billets	61	1142	1003	816	508	61	33	
486									
487	End of period vacancy vector v(t):								
488	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
489	v(t)	0	-1	0	0	0	0	0	
490									

	AU	AV	AW	AX	AY	AZ	BA	BB	BC
443	First Calculation of Vacancy Model (Year 5)								
444									
445									
446	Total Vacancies (v(t-1) + e(t-1) w + m):								
447	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
448	TV	16.10332	217.8168	40.4804	35.5056	17.6699	16.5571	3.1944	
449									
450	Vacancy Vector v(t): Equals number of vacancies that appear in each paygrade.								
451	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
452	Vacancy	37.60455	331.6211	117.16	74.24405	37.79621	19.7515	3.1944	
453									
454	Recruitment Vector (Rj): From the vacancy model.								
455	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
456	Recruits	29	305	10	2	1	0	0	
457	Min Rec	9	91						
458	Max Rec	52	548						
459	R > Max	29	305						
460	Final Rec	29	305						
461									
462	Recruitment Vector (Rj): From vacancy model with recruitment constraints.								
463	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
464	Recruits	29	305	10	2	1	0	0	
465									
466	Allowed Promotion rates:								
467	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
468	LAST rate	0	0.469697	0.145519	0.084677	0.075426	0.03071	0.084746	
469	Promotion	0	22	105	72	37	19	3	
470	Max #	0	32	217	138	102	43	8	
471	Min #	0	26	106	35	21	0	2	
472	P > Max	0	22	105	72	37	19	3	
473	Final P	0	26	106	72	37	19	3	
474									
475	Constrained								
476	Yes/No	1	1	0	1	1	1	1	
477									
478	Demotions:								
479	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
480	Demoted	8	5	1	1	0	0	0	
481									
482	Temporary End of Year Values:								
483	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	

	AU	AV	AW	AX	AY	AZ	BA	BB	BC
484	Inventory	56	1146	1003	817	508	60	33	
485	Billets	61	1142	1003	816	508	61	33	
486									
487	End of period vacancy vector v(t):								
488	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
489	v(t)	5	-4	0	-1	0	1	0	
490									

APPENDIX D
MK 1993 MODEL

	A	B	C	D	E	F	G	H	I	J
1	**COAST GUARD RATING FORECAST MODEL**									
2	By: LCDR Mark J. FIEBRANDT									
3	24 Sept. 1993									
4										
5	This model forecasts manpower requirements for a specific CG rating over a five year period of									
6	time. The model will provide for each paygrade annual stocks and flows along with mean Time									
7	in Service for each flow group.									
8	The model requires input of certain historical data and model starting point values in order									
9	to estimate certain model parameters and forecast future system movements. The following									
10	pages of this spreadsheet will be for input of data. Cells which require to be filled are hi-lighted by									
11	a gray box. Note that the historical data consists of eight consecutive years of information. It									
12	is not completely necessary to have the full eight years but should have at a minimum of four									
13	years. In any case the most recent year of data gets filled in the bottom row of historical data									
14	matrices and proceeds upwards to less recent years.									
15	Lines 20 through 84 (Data Entry Section) contain questions which are for a specific model,									
16	whereas lines 85 through 235 (Historical Data Input Section) are generic for model year and rating.									
17	This means once the Historical Data Input Section is filled, different model runs may be made by									
18	changing values in the Data Entry Section. It is recommended that the Historical Data Input									
19	Section be filled in first, then the Data Entry Section completed to run a specific model.									
20										
21										
22										

	A	B	C	D	E	F	G	H	I	J
23	**DATA ENTRY SECTION**									
24										
25	What rating do you wish to forecast for?					MK				
26										
27	What fiscal year does the model start its forecast?						1993			
28										
29	What are the beginning of year personnel inventories e(t-1), for the							MK	rating?	
30	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	Total	
31	Inventory	135	1259	978	812	508	59	33	3784	
32										
33	What are the beginning of year number of billets, n(t-1), for the							MK	rating?	
34	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	Total	
35	Inventory	62	1113	990	814	508	57	32	3576	
36										
37	What are the average Time in Service (TIS) values for beginning of year personnel inventories?									
38	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9		
39	Inventory	1.595	4.029	9.012	13.273	16.331	19.641	23.581		
40										
41	What are the end of first year forecasted number of billets, n(t), for the							MK	rating?	
42	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	Total	
43	Inventory	61	1143	1003	816	508	61	33	3625	
44										
45	What additional changes in number of billets n(t) may occur in the first year?									
46	Note: Positive values will increase the # of billets while negative values decrease the # of billets.									
47	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	Total	
48	Deltas	0	0	0	0	0	0	0	0	
49										
50	What is the forecasted billets growth/accession (in percentages) for years two through five?									
51	Note: A 5% annual growth rate would be represented by 1.05 and is compounded each year.									
52	ie. A 5% accession (0.95) would be 95% of previous years billets. The rate for								1993	was
53	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9		
54	1993	0.98387	1.02695	1.01313	1.00246	1	1.07018	1.03125		
55	Forecasted rates are:									
56	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9		
57	1994	0.95	0.95	0.95	0.95	0.95	0.95	0.95		
58	1995	0.95	0.95	0.95	0.95	0.95	0.95	0.95		
59	1996	0.95	0.95	0.95	0.95	0.95	0.95	0.95		
60	1997	0.95	0.95	0.95	0.95	0.95	0.95	0.95		
61										

	A	B	C	D	E	F	G	H	I	J
62	What is the forecasted attrition rates for years one through five?									
63	Note: The rates inputted are the exact rates used by the model and represent all attrition									
64	from the rating. The previous year's attrition rates are:									
65	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9		
66	Rate:	0.27586	0.21781	0.08395	0.03436	0.13654	0.23636	0.10345		
67	Forecasted rates are:									
68	Paygrade	E-2/3	E-4	E-5	E-6	E-7	E-8	E-9		
69	1993	0.27586	0.1689	0.0582	0.0388	0.0731	0.2203	0.0968		
70	1994	0.27586	0.1689	0.0582	0.0388	0.0731	0.2203	0.0968		
71	1995	0.27586	0.2178	0.07	0.0388	0.0731	0.2203	0.0968		
72	1996	0.27586	0.1689	0.0582	0.0388	0.0731	0.2203	0.0968		
73	1997	0.27586	0.1689	0.0582	0.0388	0.0731	0.2203	0.0968		
74										
75	What is the maximum allowed change in promotion rates from year to year (In percentages)?									
76	The current promotion rates are:									
77	Paygrade		E-4	E-5	E-6	E-7	E-8	E-9		
78	Rate		0.65517	0.18877	0.13431	0.11288	0.04615	0.09091		
79	Paygrade		E-4	E-5	E-6	E-7	E-8	E-9		
80	% Change Up		0.05	0.05	0.05	0.05	0.05	0.05		
81	% Change Down		0.05	0.05	0.05	0.05	0.05	0.05		
82										
83	What is the minimum r squared allowed for using linear regression as a TIS predictor?									
84	Values 0 to 1.0. Recommend 0.8.				0.8					
85										
86										
87	What is the minimum and maximum annual number of "A" school graduates allowed?									
88	Min #	100								
89	Max #	600								
90										
91	**HISTORICAL DATA INPUT SECTION**									
92										
93	What years of historical data is available? See ANNUAL DATA chart for years.									
94	First Year:	1984								
95	Last Year:	1992								
96										
97	What weights do you wish to place on the annual historical data?									
98	Year	1984	1985	1986	1987	1988	1989	1990	1991	
99	Weight	1	2	3	1	5	6	7	8	
100										

	A	B	C	D	E	F	G	H	I	J
244	**RESULTS FOR FISCAL YEAR**					**1993**				
245										
246										
247	**Beginning of Year Values:**									
248	Paygrade:		E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	Total
249	Inventories: e(t-1)		135	1259	978	812	508	59	33	3784
250	Billets: n(t-1)		62	1113	990	814	508	57	32	3576
251	Inventory TIS:		1.595	4.029	9.012	13.273	16.331	19.641	23.581	N/A
252	Attrition Rate: w		0.27586	0.1689	0.0582	0.0388	0.0731	0.2203	0.0968	N/A
253										
254										
255	**Flows for fiscal year**			**1993**						
256	Values are number moved to that paygrade during the fiscal year.									
257	Paygrade:		E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	Total
258	Promotions:		0	82	175	90	55	18	3	423
259	Recruitment:		39	194	13	2	1	0	0	249
260	Attrition:		37	213	57	32	37	13	3	392
261	Demotions:		6	2	2	1	0	0	0	11
262										
263										
264	**Time In Service Mean Values:**									
265	Values are mean TIS for those moved to that paygrade during the year.									
266	See Flows box above for number moved.									
267	Paygrade:		E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
268	TISADV: Promotees		0	1.23067	4.75359	10.8561	14.6964	18.6548	19.9984	
269	TIS: Attritees		2.05604	4.07923	7.79306	14.2278	18.0428	20.398	24.173	
270	TIS: Recruited		0.63076	2.80524	7.37262	14.2305	16.9158	14.675	23.581	
271	TIS: Demoted		4.20505	10.1343	13.4236	16.3144	19.641	23.581	0	
272										
273										
274	**End of Year Values:**									
275	Paygrade:		E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	Total
276	Inventory: e(t)		61	1143	1019	816	508	61	33	3641
277	Billets: n(t)		61	1143	1003	816	508	61	33	3625
278	Inventory TIS:		1.70765	4.26678	8.98507	13.7648	16.838	19.876	24.1106	N/A
279										
280	*diff*		0	0	-16	0	0	0	0	
281										

	A	B	C	D	E	F	G	H	I	J
293	**RESULTS FOR FISCAL YEAR**					**1994**				
294										
295										
296	**Beginning of Year Values:**									
297	Paygrade:		E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	Total
298	Inventories: e(t-1)		61	1143	1019	816	508	61	33	3641
299	Billets: n(t-1)		61	1143	1003	816	508	61	33	3625
300	Inventory TIS:		1.70765	4.26678	8.98507	13.7648	16.838	19.876	24.1106	N/A
301	Attrition Rate: w		0.27586	0.1689	0.0582	0.0388	0.0731	0.2203	0.0968	N/A
302										
303										
304	**Flows for fiscal year**			**1994**						
305	Values are number moved to that paygrade during the fiscal year.									
306	Paygrade:		E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	Total
307	Promotions:		0	34	102	43	23	11	1	214
308	Recruitment:		42	208	1	0	0	0	0	251
309	Attrition:		17	193	59	32	37	13	3	354
310	Demotions:		7	2	0	0	0	0	0	9
311										
312										
313	**Time In Service Mean Values:**									
314	Values are mean TIS for those moved to that paygrade during the year.									
315	See Flows box above for number moved.									
316	Paygrade:		E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
317	TISADV: Promotees		0	1.31759	5.22655	10.8201	15.192	19.2339	20.2377	
318	TIS: Attritees		2.20126	4.31997	7.77086	14.755	18.6029	20.6421	24.7159	
319	TIS: Recruited		0.67531	2.9708	7.35059	14.7578	17.4409	14.8506	24.1106	
320	TIS: Demoted		4.45321	10.104	13.921	16.8209	19.876	24.1106	0	
321										
322										
323	**End of Year Values:**									
324	Paygrade:		E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	Total
325	Inventory: e(t)		59	1085	1018	804	483	58	31	3538
326	Billets: n(t)		58	1086	953	775	483	58	31	3444
327	Inventory TIS:		1.55056	4.6109	9.49636	14.4736	17.5222	20.3867	24.8948	N/A
328										
329	diff		-1	1	-65	-29	0	0	0	
330										

	A	B	C	D	E	F	G	H	I	J
343	**RESULTS FOR FISCAL YEAR**					**1995**				
344										
345										
346	**Beginning of Year Values:**									
347	Paygrade:		E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	Total
348	Inventories: e(t-1)		59	1085	1018	804	483	58	31	3538
349	Billets: n(t-1)		58	1086	953	775	483	58	31	3444
350	Inventory TIS:		1.55056	4.6109	9.49636	14.4736	17.5222	20.3867	24.8948	N/A
351	Attrition Rate: w		0.27586	0.2178	0.07	0.0388	0.0731	0.2203	0.0968	N/A
352										
353										
354	**Flows for fiscal year**			**1995**						
355	Values are number moved to that paygrade during the fiscal year.									
356	Paygrade:		E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	Total
357	Promotions:		0	30	43	0	22	11	1	107
358	Recruitment:		36	200	0	0	0	0	0	236
359	Attrition:		16	236	71	31	35	13	3	405
360	Demotions:		6	2	0	0	0	0	0	8
361										
362										
363	***Time* In Service Mean Values:**									
364	Values are mean TIS for those moved to that paygrade during the year.									
365	See Flows box above for number moved.									
366	Paygrade:		E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
367	TISADV: Promotees		0	1.19638	5.91104	11.5036	15.9063	20.0155	20.7576	
368	TIS: Attritees		1.99876	4.66838	8.19224	15.5147	19.3589	21.1724	25.5198	
369	TIS: Recruited		0.61319	3.2104	7.76887	15.5177	18.1496	15.2321	24.8948	
370	TIS: Demoted		4.81237	10.6789	14.6378	17.5044	20.3867	24.8948	0	
371										
372										
373	**End of Year Values:**									
374	Paygrade:		E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	Total
375	Inventory: e(t)		55	1032	988	751	459	55	29	3369
376	Billets: n(t)		55	1032	905	736	459	55	29	3271
377	Inventory TIS:		1.59201	4.95869	10.3881	15.3886	18.197	20.92	25.653	N/A
378										
379	diff		0	0	-83	-15	0	0	0	
380										

	A	B	C	D	E	F	G	H	I	J
393	**RESULTS FOR FISCAL YEAR**					**1996**				
394										
395										
396	**Beginning of Year Values:**									
397	Paygrade:		E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	Total
398	Inventories: e(t-1)		55	1032	988	751	459	55	29	3369
399	Billets: n(t-1)		55	1032	905	736	459	55	29	3271
400	Inventory TIS:		1.59201	4.95869	10.3881	15.3886	18.197	20.92	25.653	N/A
401	Attrition Rate: w		0.27586	0.1689	0.0582	0.0388	0.0731	0.2203	0.0968	N/A
402										
403										
404	**Flows for fiscal year**			**1996**						
405	Values are number moved to that paygrade during the fiscal year.									
406	Paygrade:		E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	Total
407	Promotions:		0	25	0	0	22	11	2	60
408	Recruitment:		33	67	0	0	0	0	0	100
409	Attrition:		15	174	58	29	34	12	3	325
410	Demotions:		4	1	0	0	0	0	0	5
411										
412										
413	**Time In Service Mean Values:**									
414	Values are mean TIS for those moved to that paygrade during the year.									
415	See Flows box above for number moved.									
416	Paygrade:		E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
417	TISADV: Promotees		0	1.22836	6.60283	12.6959	16.8285	20.7864	21.3006	
418	TIS: Attritees		2.05219	5.02051	8.92718	16.4956	20.1044	21.7262	26.297	
419	TIS: Recruited		0.62958	3.45255	8.49841	16.4987	18.8486	15.6306	25.653	
420	TIS: Demoted		5.17536	11.6817	15.5632	18.1785	20.92	25.653	0	
421										
422										
423	**End of Year Values:**									
424	Paygrade:		E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	Total
425	Inventory: e(t)		52	947	929	700	436	52	28	3144
426	Billets: n(t)		52	980	860	699	436	52	28	3107
427	Inventory TIS:		1.58743	5.65027	11.4779	16.2975	18.8634	21.4795	26.2017	N/A
428										
429	diff		0	33	-69	-1	0	0	0	
430										

	A	B	C	D	E	F	G	H	I	J
443	**RESULTS FOR FISCAL YEAR**					**1997**				
444										
445										
446	**Beginning of Year Values:**									
447	Paygrade:		E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	Total
448	Inventories: e(t-1)		52	947	929	700	436	52	28	3144
449	Billets: n(t-1)		52	980	860	699	436	52	28	3107
450	Inventory TIS:		1.58743	5.65027	11.4779	16.2975	18.8634	21.4795	26.2017	N/A
451	Attrition Rate: w		0.27586	0.1689	0.0582	0.0388	0.0731	0.2203	0.0968	N/A
452										
453										
454	**Flows for fiscal year**			**1997**						
455	Values are number moved to that paygrade during the fiscal year.									
456	Paygrade:		E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	Total
457	Promotions:		0	21	0	11	20	10	2	64
458	Recruitment:		28	127	0	0	0	0	0	155
459	Attrition:		14	160	54	27	32	11	3	301
460	Demotions:		4	1	0	0	0	0	0	5
461										
462										
463	**Time In Service Mean Values:**									
464	Values are mean TIS for those moved to that paygrade during the year.									
465	See Flows box above for number moved.									
466	Paygrade:		E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	
467	TISADV: Promotees		0	1.22483	7.97847	14.1529	17.7444	21.5476	21.8703	
468	TIS: Attritees		2.04628	5.72072	9.82534	17.4699	20.8407	22.3073	26.8595	
469	TIS: Recruited		0.62777	3.93407	9.38998	17.4732	19.5389	16.0486	26.2017	
470	TIS: Demoted		5.89716	12.9073	16.4824	18.8443	21.4795	26.2017	0	
471										
472										
473	**End of Year Values:**									
474	Paygrade:		E-2/3	E-4	E-5	E-6	E-7	E-8	E-9	Total
475	Inventory: e(t)		49	932	863	664	414	49	27	2998
476	Billets: n(t)		49	931	817	664	414	49	27	2951
477	Inventory TIS:		1.76211	6.15146	12.5456	17.1542	19.5434	22.0875	26.7337	N/A
478										
479	diff		0	-1	-46	0	0	0	0	
480										

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